Australasian
Groundwater & Environmental
Consultants Pty Ltd

REPORT on

KINNEARS QUARRY
ACID ROCK DRAINAGE

GROUNDWATER ASSESSMENT

prepared for
TWEED SHIRE COUNCIL

Project No. G1495
October 2010

ABN:64 080 238 642

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REPORT ON

KINNEARS QUARRY ACID ROCK DRAINAGE

GROUNDWATER ASSESSMENT

1.0 INTRODUCTION

Tweed Shire Council (TSC) owns and operates the Kinnears Quarry which is a hard rock quarry located on Harry's Road off Numinbah Road at Crystal Creek approximately 6km west of Murwillumbah. The project site is described as Lot 1 on DP 1004207. Development of the quarry has resulted in acid rock drainage (ARD) from water flowing from the site into an adjacent unnamed creek located along the site's western boundary (hereafter referred to as Site Creek). In July 2009, Ecoroc Pty Ltd[1] (Ecoroc) undertook an initial appraisal of the likely cause of the ARD condition and provided advice on what investigations and remedial treatment options were available to address the problem at the site. Review of this assessment by the NSW Department of Environment, Climate Change and Water (DECCW) resulted in TSC being issued with a Prevention Notice on 29 September 2009 which detailed a number of short to medium term remedial actions, and included the need for an assessment of the groundwater regime at the site.

In response to the above, TSC commissioned Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to undertake a hydrogeological investigation of the groundwater regime within the site which included installation of a groundwater monitoring network to satisfy the requirements of the Prevention Notice. This report describes the rational behind establishing the groundwater monitoring network, the findings and results of the monitoring bore installation and the results of the groundwater and surface water monitoring undertaken over a six month period.

2.0 BACKGROUND

The Prevention Notice issued by DECCW specifies the need to conduct a groundwater investigation to assess the extent of influence groundwater may have on the generation of acid water and metalliferous discharge from the quarry into the adjacent Site Creek. To facilitate this, the Prevention Notice outlines the following minimum works to be included to achieve this purpose:

- *The utilization of at least three groundwater wells to determine groundwater flow rate and flow direction.*
- *Monthly monitoring of groundwater quality for pH, electrical conductivity (EC), dissolved oxygen, total and dissolved metals.*

[1] Ecoroc Pty Ltd, (July 2009), *"Report on Acid Rock Drainage (ARD) Investigations and Remedial Solutions"*, report prepared for Tweed Shire Council.

- *Reference to surface water quality monitoring data being undertaken separately.*
- *Assessment of the relative contributions of ground and surface waters to acid and metalliferous discharge from the site.*

The Prevention Notice specified an interim report be provided eight months after commencement of the groundwater investigation to which it was assumed that six monthly events be completed at the end of this period. A scope of work was developed to satisfy the above requirements and included six monthly sampling and monitoring events of groundwater and surface water within the site.

3.0 EXISTING ENVIRONMENT

3.1 Site Description and Topography

The site making up Kinnears Quarry is located along the western slopes of a northerly trending ridgeline which also includes two other quarries; Singh's quarry adjacent to the site's eastern boundary, and Sandercock's Quarry adjacent to the southern boundary (refer Drawing No. 1.) Access to the site is via Harry's Road off North Arm Road. The quarry is located along the western slope of this ridgeline, which extends from ~RL70m AHD at the quarry's highest point to ~RL22m AHD along Harry's Road. West of Harry's Road within the western portion of the site, the topography slopes downwards into a deeply incised gully which contains the Site Creek, and drains northwards into the Rous River. The western side of this gully slopes steeply upwards to another ridgeline that includes rural residential properties. Within the site, the Site Creek is characterised by a layer of orange-brown iron hydroxide precipitate along its course (see Figure 1).

Figure 1: Iron hydroxide precipitate in the Site Creek

Development of the quarry includes four benches and associated batters which are referred to as Bench 1, 2, 3 and 4, with Bench 1 being the lowest adjacent to Harry's Road and Bench 4 the highest. Stormwater runoff from the undisturbed land within the steep, wooded Kinnears Quarry site flows westerly into Site Creek, whilst runoff from the disturbed worked portions of the quarry area is directed via surface channels and contours into two small sediment ponds established at the base of the quarry working area. Overflow from these sediments ponds reports via a pipe under Harry's Road into Site Creek.

Where the site has not been disturbed by quarry activities, these areas remain well vegetated with rainforest and wet sclerophyll forest with no obvious signs of stressed, dying or dead vegetation.

The extent of the features described above is shown in Drawing No. 1.

Discussions with the TSC Quarry Manager (pers Comms Mr Athol Kiem, 26 May 2010) have identified that the quarry was privately owned prior to TSC taking over its ownership and operation in 1991, but that little is known about its operation during this time other than:

- the quarry commenced operation sometime in the 1960's;
- the quarry apparently extended down towards Site Creek adjacent to the two site sedimentation ponds; and
- The current batter between the sedimentation ponds and Site Creek, which includes and part of the southern extent of Harry's Road, comprises backfill material presumably sourced from the quarry.

3.2 Geology

The Tweed Heads 1:250,000 scale geological map of the region indicates the quarry site and surrounding areas are located within an relatively extensive area of Upper Devonian to Carboniferous aged Neranleigh-Fernvale Beds meta-sediments comprising sequences of greywacke, quartzite, phyllite, meta-siltstone and shale, which make up the basement geology within study area and surrounds. North of the site, this geology is overlain by Quaternary aged alluvial sediments (gravels, sand and clay) associated with the Rous River alignment.

Locally, the site comprises predominantly of quartzite and lesser (meta) siltstone. An interbedded sequence ('lens') of carbonaceous shale outcrops within Bench 2 and Bench 3 comprising a discrete bed or pod of black, soft, graphitic clay shale which is mineralised with finely disseminated sulphides (predominantly iron pyrites)[2]. Exposure of this geological unit by quarrying and removal of overlying quartzite and siltstone sequences appears to have resulted in oxidation of these sulphides and the resultant generation of ARD conditions.

4.0 MONITORING BORE DRILLING AND CONSTRUCTION

4.1 Objective

The purpose of the quarry groundwater assessment as detailed in the Prevention Notice was two fold:

[2] Geobas, (June 2009), *"Kinnears Quarry – Tweed Shire Council Acid Rock Drainage Investigation, Geological Assessment and Quarry Development Report"*, report prepared for Tweed Shire Council.

1. to investigate the extent and depth of groundwater within the site that has the potential to intersect the acid forming carbonaceous shale material; and
2. to establish a monitoring bore network that can be used for long-term monitoring of the groundwater associated with the site.

On the basis that the groundwater table can generally be inferred as a subdued reflection of the site topography, that is the groundwater levels would be expected to be higher along the eastern side of the site compared to those within the western side, consideration was given to locating the monitoring bores such that they would intersect groundwater:

- up-gradient of the quarry that would be representative of 'background' groundwater quality that has not been affected by site activities or release of ARD; and
- down-gradient of the quarry that would be representative of 'detection' groundwater quality where the groundwater regime is likely to have been impacted by the ARD.

To achieve this, four groundwater monitoring bores (MB1, MB2, MB3 and MB4) were drilled and constructed on 28 and 29 January 2010. The monitoring bores were drilled and constructed by Universal Drilling under supervision of an AGE hydrogeologist. The boreholes were drilled with a Rapid Fire 150 drilling rig using conventional rotary air blast (RAB) methods. A 95mm diameter borehole was drilled at each site with chip samples collected at 1m intervals and logged on-site.

The locations of the monitoring bores were as follows:

- MB1 along the access track to Singh's Quarry to intersect representative background groundwater quality that is hydraulically up-gradient of the quarry;
- MB2 and MB3B on the either side of Bench 2 to intersect any shallow groundwater seepage and monitor groundwater quality impacted by the ARD in that area; and
- MB4 along the site access on Harry's Road to intersect and monitor groundwater quality hydraulically down-gradient of the quarry potentially impacted by the ARD.

The locations for the monitoring bores are shown in Drawing No. 1.

4.2 Lithology and Groundwater Inflow

The drilling generally intersected interbedded sequences of weathered to fresh quartzite and siltstone, with some phyllite intersected in MB1 and carbonaceous shale in bores MB3A and MB3B. Bore MB3A was drilled initially but the borehole collapsed after the drill rods were removed. A second attempt (bore MB3B) was drilled approximately 10m away which remained open and was constructed as a monitoring bore.

Bore MB1 drilled "dry" with only slightly moist drill cuttings observed during drilling. However, on completion of drilling to 80m, the bore was left open for one hour after which time a slowly recovering groundwater level was measured within the base of the bore. Bores MB2 and MB4 both intersected groundwater inflows at 12m in quartzite, whilst bore MB3A and MB3B intersected groundwater at 3m to 4m depth. Summary details of the geological sequences intersected, their depth and the depth of groundwater intersection are provided in Table 1. Borehole logs are included in Appendix A.

Table 1: SUMMARY BOREHOLE GEOLOGY AND GROUNDWATER DETAILS			
Bore ID	**Depth (m)**	**Geology**	**Groundwater Intersection Details**
MB1	0-20 20-46 46-80	Interbedded Quartzite / Siltstone, highly to moderately weathered Interbedded Phyllite / Siltstone, highly weathered to fresh (from 43m) Interbedded Quartzite / Siltstone, fresh	Dry to slightly moist. No groundwater inflow noted during drilling. Minor groundwater measured at base of bore on completion of drilling to 80m.
MB2	0-6 6-15	Interbedded Quartzite / Siltstone, slightly weathered to fresh (from 4m) Quartzite, fresh	Moist returns at 12m, wet from 13m.
MB3A	0-3 3-8 8-10	Interbedded Quartzite / Siltstone, slightly weathered to fresh (from 4m) Quartzite, fresh Carbonaceous Shale, fresh	Wet from 4m.
MB3B	0-4 4-6 6-7 7-9	Quartzite, moderately weathered to fresh Interbedded Quartzite / Siltstone, slightly weathered to fresh (from 6m) Quartzite, fresh Interbedded Quartzite / Siltstone, Carbonaceous Shale, fresh	Wet from 3m.
MB4	0-7 7-11 11-19 19-21	Interbedded Quartzite / Siltstone, moderately weathered to fresh (from 7m) Quartzite, fresh Interbedded Quartzite / Siltstone, fresh Quartzite, fresh	Moist returns at 12m, wet from 13m.

4.3 Monitoring Bore Construction

At each site, a 95mm diameter hole was drilled to total depth and then completed as a monitoring bore (with the exception of bore MB3A) by running 50mm Class 12 casing to the base of each borehole. Depending on the extent of the zone of groundwater inflow, between 3m to 12m of factory slotted screen was placed at the base of each borehole, with blank PVC casing then placed to the ground surface. In Bore MB1, 3m blank sections were placed in between each screen effectively placing the screened section over 21m. A clean, 3-6mm gravel filter was placed by gravity around the screened sections and a 1m thick bentonite seal (¼ inch bentonite pellets) then placed above the gravel pack. The remaining bore annulus was backfilled with filter gravel, followed by a 6m thick cement/bentonite grout plug placed to the ground surface to seal the hole from surface water inflows. The construction details for each monitoring bore are summarised in Table 2 below.

Table 2: MONITORING BORES CONSTRUCTION DETAILS

Bore ID	Geology/ Aquifer Intersected	Coordinates		Bore RL (mAHD)	Bore Depth (mbGL)	Screen Zone (from-to [m])		Static Water Level		
		Easting (m)	Northing (m)					Date	mbTOC	mAHD
MB1	Interbedded Quartzite/Siltstone	533046.16	6867181.76	67.85	80	59	80	9/02/10	34.175	34.30
MB2	Quartzite	533005.37	6867027.10	32.37	15	9	15	9/02/10	1.135	31.93
MB3B	Interbedded Quartzite/Siltstone/ Carbonaceous Shale	532972.75	6867029.65	31.41	9	6	9	9/02/10	1.39	30.76
MB4	Interbedded Quartzite/Siltstone	532931.22	6867085.57	21.90	21	15	21	9/02/10	+0.91	23.51

Note: Survey datum is MGA 94 Zone 56.
mAHD – metres Australian Height Datum.
mbGL – metres below ground level.
mbTOC – metres below top of casing.
RL – reduced level (elevation)

Following completion of construction as monitoring bores, each was airlift developed to remove drilling fines and enhance hydraulic connection between the monitoring bore and aquifer.

5.0 SITE HYDROGEOLOGY

The regional geological mapping, site geology and the results of the monitoring bore drilling has identified that the hydrogeological regime of the site is dominated by a fractured rock aquifer associated with the quartzite, and to a lesser extent siltstone in the Neranleigh-Fernvale Beds. The extent of this aquifer is discussed below.

5.1 Fractured Rock Aquifer

The aquifer within the site is associated with fractured quartzite and siltstone sequences which are considered to be semi-confined to confined beneath a semi permeable surficial weathered profile. The hydraulic properties of the aquifer for permeability (hydraulic conductivity) and storativity (aquifer storage potential) are a function of secondary porosity features, such as fracturing, faulting and jointing which are structural features that would have developed subsequent to the host rock's emplacement. The permeability of this type of aquifer therefore depends on the extent of the interconnection between these open fractures and joints.

Recharge to this aquifer is by direct infiltration (seepage) of rainfall and surface water flows where these structural features sub-crop or outcrop at the ground surface, particularly within drainage channels and the exposed quarry surface.

5.2 Groundwater Levels

Groundwater levels recorded after water levels had stabilised following monitoring bore development ranged from approximately 1.0m above ground level at the down-gradient site MB4 (i.e., artesian flow conditions) to 34.2m below ground level at the up-gradient site MB1. The

reduced levels at each site ranged from RL34.3m in MB1 to RL23.6m in MB4 (refer Table 2). That is within the site, the groundwater flow direction is from the east to west down slope towards the Site Creek / gully. As discussed in Section 4.1, the resultant potentiometric surface[3] is a subdued reflection of the ground surface with an overall gradient of 0.07. This groundwater potentiometric surface is depicted in Drawing No. 2 and shows it is higher than the surrounding quarried surface along Bench 1 intersecting the batter slope between Benches 1 and 2. This infers groundwater should discharge (as groundwater seepage) from this batter slope, as was observed after rainfall periods by the damp surface and iron staining along the exposed batters adjacent to (upslope of) the Sedimentation Pond (KIN4 – refer Figure 2).

Figure 2: Seepage from exposed Bench 2 Batter above Sedimentation Pond

Hydrographs of groundwater level measurements and daily rainfall totals recorded over the six month monitoring period between February and August 2010 are presented in Appendix B. These show groundwater levels responding to rainfall events, particularly within the quarried areas where enhanced seepage of surface water runoff occurs via exposed fractured rock surfaces within the quarry catchment area.

Over the period of monitoring, groundwater levels in:

- MB1 ranged from RL34.4m in February up to RL37.6m in May and then declined back to RL34.4m by August. Notable rises in groundwater levels in response to rainfall were observed after the significant rainfall events on 7 February, 2 March and 4 May.
- MB2 showed a smaller range from RL32m in March to RL30.3m in August. In general responses to rainfall were small (up to 0.6m), but occurred after most rainfall events

[3] A potentiometric surface is an imaginary surface representing the groundwater pressure head in a confined aquifer. It is analogous to the actual water level if it were within an unconfined aquifer (i.e., the water level at atmospheric pressure).

indicating the quarried bench surfaces comprise numerous open fractures which direct seepage from surface water flows directly into the groundwater surface.

- MB3B showed a larger range from RL30.8m down to RL25.6m in August following a period of minimal rainfall after the end of May. The notable decline in groundwater levels at the end of May would be a function of the free draining nature of the fractured rocks within that portion of the quarry and the bores close proximity to the Bench 2 batter. However, in general the groundwater levels in this bore showed a similar response to that observed in MB2 which is to be expected given the bore location within the quarry.
- MB4 generally declined from RL23.6m to RL22.4m, but still remained as artesian flow conditions. No data was recorded after the start of monitoring to the end of March due to data logger failure. Responses to rainfall events were mostly subdued with the only notable rise around 0.3m observed in May. The minor fluctuations observed are most likely caused by changes in atmospheric conditions.

Overall, the rapid rise and fall observed in these groundwater levels, in particular within the quarried bench areas, indicate the aquifer to be of moderate to high permeability with a low storage potential.

6.0 WATER SAMPLE COLLECTION AND ANALYSIS

6.1 Sampling and Analysis Methodology

Following completion of the monitoring bore drilling, construction and bore development, monthly monitoring and sampling from the each monitoring bore was undertaken over the six month period between February and August 2010.

Due to depth of water in bore MB1 and the need for monitoring for dissolved oxygen, pH and dissolved metals, it was considered that using a conventional submersible pump would not be capable nor suitable for collecting representative groundwater samples from these bores. Instead, it was decided a HydraSleeve in-situ sampling device would be more appropriate as these are specifically designed for collection of undisturbed groundwater samples from the screened zone in the bore. The HydraSleeve works on the principle that the groundwater contained within the screened section of a monitoring bore is in dynamic equilibrium with the surrounding aquifer/ formation where groundwater flow through the screen is primarily horizontal with little or no mixing with the overlying water column. That is, the HydraSleeve is placed into the bore screened section and then left in place whilst the groundwater in this section of the bore equilibrates with the surrounding water outside the monitoring bore. The HydraSleeve is then retrieved and an undisturbed “slug” of representative sample of groundwater is collected within the sampling tube. When full, a non return flap valve closes the top of the sleeve preventing mixing of other water higher up in the bore, or oxygen with the groundwater sample.

A HydraSleeve sampling tube was placed at the base of each bore adjacent to the screened section, allowing collection of representative groundwater samples from each of the monitoring bores and characterisation of the groundwater chemistry. The HydraSleeve was replaced after each successive monthly monitoring event, and remained in-situ until the next sampling event.

Surface water samples were also collected for each monthly monitoring event from the sedimentation pond (KIN4 – see Figure 3) and the causeway across Site Creek (KIN3 – see Figure 4) at the entrance to the site along Harry’s Road, to allow comparison between this water and groundwater beneath the site.

Figure 3: Surface Water Sampling Location KIN4 (Sedimentation Pond)

Figure 4: Surface Water Sampling Location KIN3 (Site Creek)

Field determinations for electrical conductivity (EC), pH and dissolved oxygen for the groundwater samples and surface water samples using a WP-82Y dissolved oxygen and WP-81 pH-conductivity-salinity meters manufactured by TPS Electronics Pty Ltd. The instruments were calibrated prior to undertaking the work using factory-supplied calibration standard solutions.

Samples collected for laboratory analysis were stored in appropriate containers supplied by Tweed Laboratory Centre (TLC) which is NATA registered for all the laboratory analytical work performed for this assessment. Samples for dissolved metals analysis were filtered and acidified in the field. The groundwater and surface water samples were analysed for:

- pH, EC, and dissolved oxygen (field determinations only);
- Cations – calcium, magnesium, potassium, sodium;
- Anions – chloride, sulphate, alkalinity (carbonate and bicarbonate); and
- Total and dissolved metals – aluminium, cadmium, copper, iron, and manganese.

Copies of the laboratory analysis certificates are given in Appendix C and the results are discussed in Section 6.2.

6.2 Water Quality

The results of field determinations for pH, EC and dissolved oxygen for each monitoring event are presented in Appendix D and summarised in Table 3, with those reported for each monitoring event presented graphically in Appendix E.

Table 3: FIELD WATER QUALITY DATA RANGE

Site	pH	EC (µS/cm)	Dissolved Oxygen (mg/L)
MB1	6.4 – 7.3	438 – 675	0.26 – 3.29
MB2	5.6 – 6.9	387 – 654	0.15 – 0.32
MB3B	2.6 – 6.3	1,723 – 3,430	0.23 – 0.46
MB4	6.0 – 6.6	1,106 – 1,428	0.15 – 0.58
KIN3	3.4 – 3.6	343 – 403	1.39 – 6.18
KIN4	2.7 – 8.8	1,571 – 2,510	3.27 – 4.80

These indicate the groundwater quality to range from acidic (pH 2.6 – MB3B), to neutral (pH 7.3 – MB1), and fresh (387µS/cm – MB2) to slightly brackish (3,430µS/cm – MB3B). The surface water samples collected were generally acidic (pH 2.7 to 3.8), except on one occasion in July when the sedimentation pond (KIN4) was dosed with lime (see Figure 5) and reported a pH value of 8.8, and fresh (343µS/cm – KIN3) to slightly brackish (2,510µS/cm – KIN4).

Dissolved oxygen levels in the groundwater were generally very low to depleted and ranged from 0.2mg/L to 0.6mg/L with one value reported at 3.3mg/L within the background monitoring bore MB1 after its construction and is possibly an artefact of the bore development and low permeability of the strata hosting the aquifer at this location. Dissolved oxygen levels in the surface water ranged from 1.4mg/L to 6.2mg/L in the creek (KIN3) and 3.3mg/L to 4.8mg/L in the sedimentation pond (KIN4).

Dissolved oxygen levels near zero are termed anoxic whilst levels less than 2mg/L are considered a hypoxic event (condition) where the lack of oxygen becomes detrimental to aerobic aquatic organisms living in that system. In groundwater, dissolved oxygen levels are generally low and decline with depth as it is removed in the oxidation process of organic material as the water percolates downward from the ground surface through the unsaturated (vadose) zone (Driscoll, 1989[4]).

Figure 5: Lime Dosing the Sedimentation Pond in July 2010

Depleted dissolved oxygen levels will also result from the oxidation of sulphides such as pyrite (Hounslow, 1995)[5], indicating the low levels measured in the sedimentation pond at KIN4 could be a function of this process.

The results of the laboratory analyses for the samples collected following drilling and construction of the monitoring bores are summarised below in Table 4.

Table 4: GROUNDWATER AND SURFACE WATER QUALITY DATA RANGE

Analyte	Unit	LOR	MB1	MB2	MB3B	MB4	KIN3	KIN4
pH Value	pH Unit	0.1	6.4 – 7.1	5.9 – 6.3	2.6 – 5.5	6.5 – 6.7	3.6 – 3.8	2.6 – 8.8
Electrical Conductivity	µS/cm	1	396 – 614	386 – 1384	1757 – 3480	1312 – 1409	343 – 418	1671 – 2588

[4] Driscoll F.G., (1989), *"Groundwater and Wells"*, second edition, Johnson Filtration Systems Inc.

[5] Hounslow, A.W., (1995), *"Water Quality data: Analysis and Interpretation"*, Lewis Publishers.

Table 4: GROUNDWATER AND SURFACE WATER QUALITY DATA RANGE								
Analyte	**Unit**	**LOR**	**MB1**	**MB2**	**MB3B**	**MB4**	**KIN3**	**KIN4**
Major Ions								
Alkalinity as $CaCO_3$	mg/L	1	110 – 250	38 – 97	NP – 39	210 – 220	NP – <1	NP – 62
Carbonate (CO_3)	mg/L	1	NP	NP	NP	NP	NP	NP – 7
Bicarbonate (HCO_3)	mg/L	1	67 –155	23 – 59	NP – 24	127 – 135	NP – <1	NP – 31
Chloride	mg/L	3	55 – 78	22 – 53	7 – 48	12 – 30	9 – 17	4 – 13
Sulphur as Sulphate	mg/L	0.1	1.2 – 6.3	50 – 608	842 – 1495	471 – 638	94 – 132	628 – 1417
Calcium	mg/L	0.1	11 – 78	20 – 138	121 – 169	150 – 204	11 – 16	110 – 482
Magnesium	mg/L	0.1.	<5 – 19	<5 – 28	<5 – 128	<5 – 79	<5 – 9.5	<5 – 72
Sodium	mg/L	0.1	26 – 40	16 – 106	9 – 13	21 – 26	9 – 15	7.5 – 11
Potassium	mg/L	5	<5 – 7.9	<5 – 15	<5 – 86	<5 – 68	<5 – 7	<5 – 50
Trace Metals								
Aluminium (Total/Soluble)	mg/L	0.01	0.46-11/ 0.02-0.07	1.7-25.0/ 0.01-0.80	6.25-21/ 4.16-18	4.01-40.00/ 0.02-0.23	2.50-4.45/ 2.50-4.12	0.08-13.00/ 0.03-12.00
Cadmium (Total/Soluble)	mg/L	0.001	<0.001-0.002/ <0.001	<0.001-0.010/ <0.001-0.009	0.002-0.021 /0.002-0.021	<0.001/ <0.001	<0.001-0.001/ <0.001-0.001	<0.001-0.007/ <0.001-0.007
Copper (Total/Soluble)	mg/L	0.01	<0.01-0.02/ <0.01	0.06-0.64/ <0.01-0.17	0.33-2.95/ 0.17-2.27	0.04-0.19/ <0.01	0.20-0.59/ 0.16-0.54	<0.01-0.88/ <0.01-0.81
Iron (Total/Soluble)	mg/L	0.01	0.22-15/ 0.04-3.84	18.0-78.0/ 10.0-23.0	47.0-272.0/ 31.0-253.0	17.0-59.0/ 12.0-18.0	0.92-2.21/ 0.58-1.84	0.41-125/ 0.01-121
Manganese (Total/Soluble)	mg/L	0.01	4.07-6.89/ 3.64-6.57	6.41-19.0/ 5.76-15.0	50.0-86.0/ 47.0-84.0	5.78-8.27/ 5.11-7.11	4.28-8.13/ 4.10-8.13	11.0-50.0/ 8.17-48.0

Note: NP – not present

The laboratory analysis values for pH and EC were all generally similar to those measured in the field with variations observed considered acceptable.

Compared to the relatively low concentrations in the background bore (MB1), marginally elevated to elevated levels for cations and anions were recorded for:

- sulphate in bores MB2, MB3B, MB4 and surface water KIN4 from the sedimentation pond;
- calcium in bores MB2, MB3B, MB4 and surface water KIN4 from the sedimentation pond;
- magnesium in bore MB3B; and
- sodium in bore MB2.

Total metal levels (i.e., those in soluble and suspended forms), were generally in excess of those for the background bore MB1. During the period of monitoring, elevated levels were recorded for:

- aluminium levels in bores MB2, MB3B and MB4, and surface water KIN4;
- cadmium levels in bores MB2 and MB3B, and surface water KIN4;
- copper levels in bores MB2, MB3B and MB4, and surface waters KIN3 and KIN4;
- iron levels in bores MB2, MB3B and MB4, and surface water KIN4; and
- manganese levels in bores MB2, MB3B and MB4, and surface waters KIN3 and KIN4.

Total metal levels that comprised mainly soluble metal concentrations included those for:

- aluminium in bore MB3B and surface waters KIN3 and KIN4;
- cadmium (where detected above the laboratory's detection limits) in bore MB3B and surface waters KIN3 and KIN4;
- copper in bore MB3B and surface waters KIN3 and KIN4;
- iron in bores MB2 and MB3B, and surface water KIN4 (and to a lesser extent KIN3); and
- manganese in all bores and surface water sampling sites.

These variations in soluble and suspended metals concentration levels are presented graphically in Appendix E.

A comparison of the ground water and surface water quality data was undertaken to identify any variation between the water quality from the two sources, as well as within the aquifer intersected across the site.

The concentrations of the major cations (Ca, Mg, Na, K) and major anions (Cl, SO_4, HCO_3) were plotted on Piper Diagrams and as Stiff Diagrams (presented in Appendix F). Both plots are graphical representations of the chemical analyses, and are used to display the major ion composition of each water sample. The Piper Diagrams provide a combination of cation and anion triangles that lie on a common baseline, and a diamond shape between the triangles which is a replot of the analyses in proportion to the sample's total dissolved salts. From this, it is possible to determine water type and hence origin of the water. Stiff Diagrams provide a polygon shape from three parallel horizontal axes extending on either side of a vertical zero axis. Stiff patterns are useful for making a visual comparison between water from different sources.

Hence, using the piper and stiff diagrams, the following comments about the site's groundwater and surface water quality can be made:

- The groundwater from the up-gradient background site (at bore MB1) is dominated by sodium, calcium, chloride, bicarbonate, whilst the down-gradient detection sites (bores MB2, MB3B and MB4) are dominated by calcium/magnesium, sulphate, as well as chloride in MB2.
- Sulphate levels increase from east to west across Bench 2 in bores MB2 to MB3B within the carbonaceous shale outcrop area.
- A decreasing sulphate content and increased calcium content in bore MB4 suggests dilution of the sulphate dominant groundwater west of the area of carbonaceous shale outcrop down-gradient of the site.
- A similar water type in bore MB3B and sedimentation pond (KIN4) suggests groundwater seepage from the Bench 1 batter slopes reports to this pond.
- Similar water chemistry for surface water downstream of the site at the causeway (KIN3) to groundwater from bores MB3B and MB4, and surface water in the sedimentation pond (KIN4), suggests discharge from the Sedimentation Pond and groundwater seepage down slope of Harry's Road impact the water quality within Site Creek.

6.3 Seepage and Additional Surface Water Quality

During the monitoring program, a seepage area was identified discharging into Site Creek down-gradient of the sedimentation pond (see Figure 6). The location of this seepage area is shown on Drawing No. 3 and is down-gradient of the Sedimentation Pond (KIN4).

Figure 6: Sampling the Seepage Point into Site Creek

The seepage area comprises a mix of angular gravel to cobble sized rock fragments within an iron stained matrix that resembles fill material and corroborates the anecdotal observation made about this area in Section 3.1.

Monthly monitoring of pH and electrical conductivity (EC) at the seepage point was undertaken by AGE and TSC between 28 April and 31 August 2010 and is presented in Table 5.

Table 5: SEEPAGE POINT WATER QUALITY FIELD DETERMINATIONS

Date	Location	pH	EC (µS/cm)
28 April	Seepage Point	3.3	1,578
	KIN4	2.6*	1,960*
26 May	Seepage Point	3.1	1,603
	KIN4	2.8	1,912
21 June	Seepage Point	3.2	2,035
	KIN4	2.8	2,510
21 July	Seepage Point	3.1	2,020
	KIN4	8.5	2,110
12 August	Seepage Point	4.9	1,550
	KIN4	5.1	1,710
31 August	Seepage Point	-	-
	KIN4	3.5	2,092

Note: * KIN4 sampled on 22 April
- insufficient sample

No sample of seepage water was able to be collected at the end of the monitoring program on 31 August due to insufficient seepage at that time.

Comparison against the Sedimentation Pond (KIN4) water quality data indicates the seepage water quality to be of similar to that for KIN4, with the only exception being on 21 July when the pond was dosed with lime raising its pH level to 8.8 (see Figure 5). It is noted that whilst the seepage water and KIN4 pH levels were again similar on the following monitoring event (12 August), the seepage water pH level was higher than that previous to the lime dosing, indicating the Sedimentation Pond contributes to seepage water discharge into Site Creek, and the rate of this seepage is relatively high.

Field determinations for pH and EC were also monitored at regular intervals along Site Creek to attempt to identify likely areas where seepage water from the quarry area could be affecting water quality within the creek. Fourteen locations (S1 to S14) located between Sandercock's Quarry and the Harry's Road culvert, were monitored on 30 June 2010. The results of this monitoring are presented in Figure 7, and show pH levels declined whilst EC levels increased between S1 upstream of Sandercock's Quarry to S14 at the Harry's Road culvert and downstream of Kinnears Quarry. More specifically, the results of this monitoring showed:

- upstream of the Sandercock's Quarry crushing area at S1 the creek water quality was slightly acidic (pH 5.8) and fresh (105µS/cm);
- a slight decrease in pH to 5.4 along with minor increase in EC to around 200µS/cm between S2 downstream of the crushing area and S4 in the southern portion of Kinnears Quarry down-gradient of the Sedimentation Pond;
- a notable decline in Site Creek pH level to 4.1 between S2 and S7 which is about 10m upstream of the seepage area identified above along with an increase in EC levels up to 370µS/cm at S7;
- low pH levels between 3.9 and 4.4 and slightly increasing EC levels up to 420µS/cm from S8 to S14 at the Harry's Road Culvert.

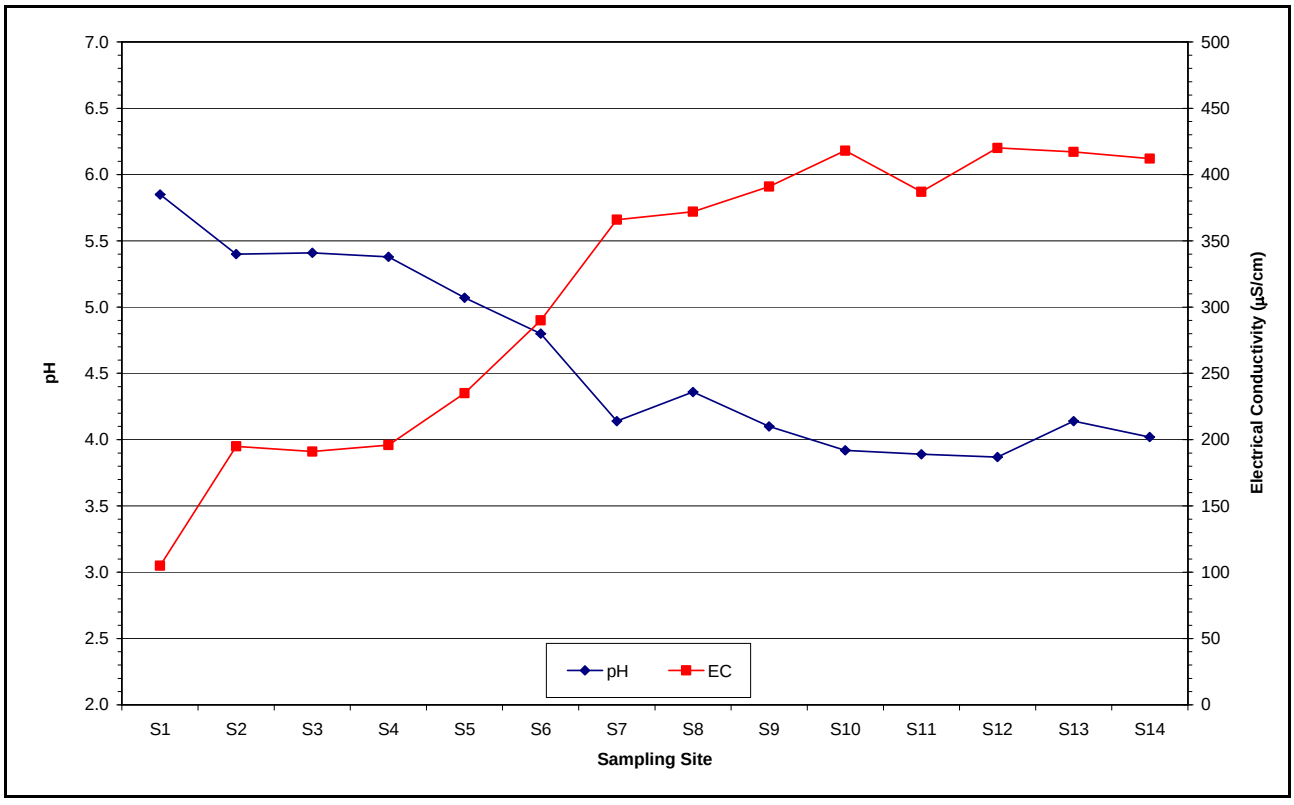


Figure 7: Levels for pH and Electrical Conductivity along Site Creek

7.0 SUMMARY

Kinnears Quarry, which is owned and operated by Tweed Shire Council (TSC), was issued with a Prevention Notice by the NSW Department of Environment, Climate Change and Water (DECCW) on 29 September 2009, which detailed a number of short to medium term remedial actions in relation to acid rock drainage (ARD) within and from the site. The Prevention Notice also detailed the need for a hydrogeological assessment of the groundwater regime within the site to assess the extent of influence groundwater may have on the generation of acid water and metalliferous discharge from the quarry into the adjacent Site Creek. This has resulted in establishing a groundwater monitoring network within the site, which has included one monitoring bore (MB1) located up-gradient of the quarry site, two monitoring bores (MB2 and MB3B) located within the quarry area (along Bench 2), and one monitoring bore (MB4) located down-gradient of the quarry.

The drilling generally intersected interbedded sequences of weathered Neranleigh-Fernvale Beds meta-sediments comprising fresh quartzite and siltstone, with some phyllite in MB1 and carbonaceous shale in bores MB3A and MB3B. The site geology and monitoring bore drilling identified the hydrogeological regime of the site being dominated by a fractured rock aquifer associated with the quartzite, and to a lesser extent siltstone and phyllite. The aquifer within the site is considered to be semi-confined to confined beneath a semi permeable surficial weathered profile, with hydraulic properties for permeability and storativity a function of secondary porosity features, such as fracturing, faulting and jointing. The extent of this aquifer is dependent on the extent of interconnection between these features. Recharged to the aquifer is by direct infiltration (seepage) of rainfall and surface water flows where these features sub-crop or outcrop at the ground surface.

Groundwater levels ranged from approximately 0.9m (RL 23.5m) above ground level (i.e., artesian flow conditions) down-gradient of the quarry to 34.1m (RL 34.4m) below ground level up-gradient of the quarry, indicating an overall groundwater gradient of 0.07. That is within the site, the groundwater flow direction is from the east to west down slope towards the Site Creek/gully. Hydrographs of groundwater level measurements and daily rainfall totals recorded over the six month monitoring period show groundwater levels responding to rainfall events. This was particularly evident within bores MB2 and MB3B along Bench 2, suggesting the quarried bench surface comprises numerous open fractures which direct seepage from surface water flows directly into the groundwater surface. The rapid rise and fall in groundwater levels observed in the monitoring bores indicates the aquifer has a low storage capacity which is typical for fractured meta-sediments.

During the six month monitoring period, water quality samples were taken from the monitoring bores and two surface water sampling points, these being the Sedimentation Pond (KIN4) and where Site Creek exits the quarry site (KIN3). Groundwater quality measurements indicated the background groundwater quality to have a neutral pH and be fresh, whilst that in the quarry area was slightly acidic to acidic and brackish. The surface water within the Sedimentation Pond was acidic and slightly brackish whilst Site Creek was acidic and fresh. Dissolved oxygen levels for both the groundwater and surface water within and adjacent to the quarry were generally very low to depleted. The laboratory analyses reported total metal levels for aluminium, cadmium, copper, iron and manganese within and down-gradient of the quarry for both groundwater and surface water, were generally in excess of those for the background bore.

Piper and Stiff Diagrams of the water quality data indicated the background groundwater quality up-gradient of the site to be dominated by sodium, chloride, bicarbonate, whilst the groundwater within and down-gradient of the quarry was dominated by calcium/magnesium, sulphate.

Overall there was an increase in sulphate concentrations from east to west across the quarry within the carbonaceous shale exposure area, with groundwater seepage from the Bench 2 batter

slopes the source for the water quality into the Sedimentation Pond. Similarities were observed in surface water chemistry downstream of the site within the Site Creek to groundwater within the quarry and the Sedimentation Pond.

These observations indicate discharge from groundwater seepage down slope of Harry's Road as the most probable source for ARD conditions impacting on water quality within Site Creek. This was supported by identification of a seepage area down-gradient of the Sedimentation Pond (KIN4) within an area of probable fill material, from which the seepage water quality was similar to that for KIN4, but where water quality monitoring along the Site Creek indicated a drop in pH and rise in electrical conductivity (EC). In July 2010, lime dosing of the Sedimentation Pond raised its pH level to 8.8 compared to 3.1 for the seepage water. The pH levels for the seepage water and KIN4 reported for the following monitoring event in August 2010 were again similar and increased to around pH 5. However, it was noted that this seepage water pH level was still higher than that reported previous to the lime dosing, indicating water from the Sedimentation Pond contributes to seepage discharge in this area.

In spite of the above, no areas of stressed or dying (dead) vegetation were identified over the duration of the six month monitoring program within the quarry study area, with the rainforest co-existent within the Site Creek gully continuing to flourish despite the acidic water quality in the creek.

In conclusion, the following comments can be made in relation to the results and findings of this hydrogeological assessment and water quality monitoring program:

- Groundwater is hosted within fractured quartzite and siltstone sequences and is recharged by direct infiltration (seepage) of rainfall and surface water flows where these features subcrop or outcrop at the ground surface, particularly within drainage channels and the exposed quarry surface.
- Development of the quarry and removal of fractured quartzite and siltstone material has most likely lowered the groundwater surface within the quarry area, which in turn has most likely contributed to oxidation of the carbonaceous shale material and generation of ARD conditions.
- Exposure to atmospheric conditions and groundwater movement (flow) through the fractured, oxidised carbonaceous shale is considered to have generated the ARD conditions and resultant discharge of acidic water quality into Site Creek via seepage areas along the eastern side of the creek.
- Preferential groundwater flow paths possibly exist within areas of backfill down slope of the quarry such as that inferred between the Sedimentation Pond and Site Creek, as indicated by the seepage area identified down-gradient of the Sedimentation Pond.

The above comments indicate the exposure of the carbonaceous shale material to atmospheric conditions and groundwater movement as the source of the acid water quality conditions in Site Creek. Taking the above into consideration, this report should be reviewed in light of the recommended remedial options outlined by Ecoroc, 2009[1] to allow for appropriate assessment of additional (and appropriate) ARD mitigation controls to be undertaken and implemented. It is understood that some of the short term mitigation options have already been implemented at the site, such as:

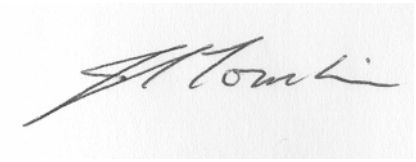
- Re-profiling the diversion drains to minimize flow of non-acidic surface water into the existing sediment ponds.
- Application of low cost alkaline material (bunds) around the base of the PAF rock face exposures.

- Monitoring water quality in the Sedimentation Pond before and after implementation of these short term treatments, along with laboratory testing of Sedimentation Pond water and Site Creek.

Whilst these short term measures may only provide a limited level of mitigation from ARD within the site, they do not address the problem in the long term. That is, whilst the carbonaceous shale material remains within the zone of water table fluctuation, the generation of acidic seepage will continue to be an issue that requires management at the site. The feasibility of long term mitigation options identified by Ecoroc such as selective removal and treatment of potentially acid forming (PAF) carbonaceous shale material, in conjunction with future quarrying options for the site and surrounds, will need to be considered if neutralising the acid water quality conditions in Site Creek must be achieved.

AUSTRALASIAN GROUNDWATER AND ENVIRONMENTAL CONSULTANTS PTY LTD

Reviewed by:



DUNCAN W. IRVINE
Senior Hydrogeologist

JAMES S. TOMLIN
Principal Hydrogeologist

LIMITATIONS OF REPORT

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has prepared this report for the use of Tweed Shire Council in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 27 November 2009.

The methodology adopted and sources of information used by AGE are outlined in this report. AGE has made no independent verification of this information beyond the agreed scope of works and AGE assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to AGE was false.

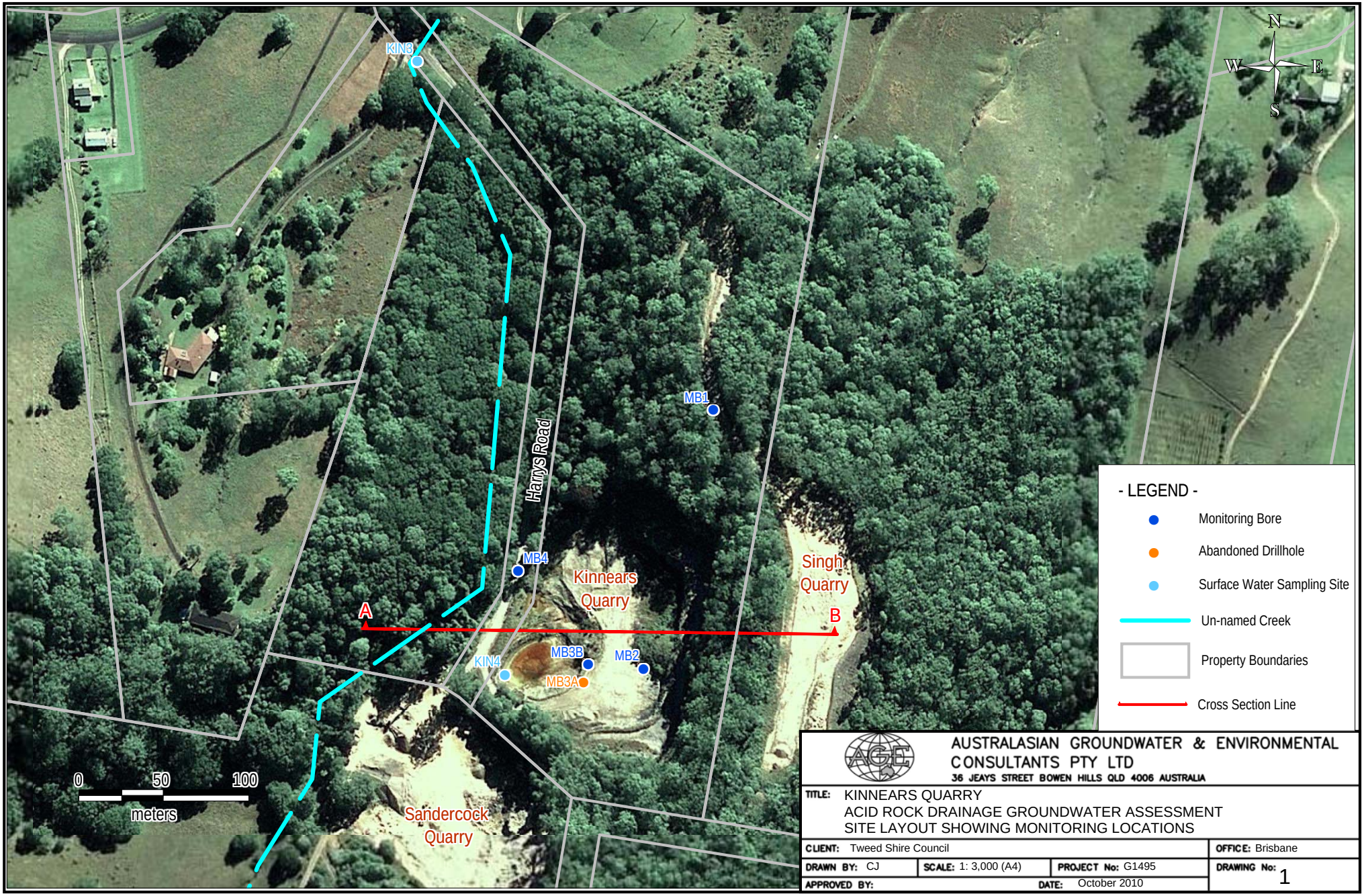
This study was undertaken between 15 December 2009 and 14 October 2010 and is based on the conditions encountered and the information available at the time of preparation of the report. AGE disclaims responsibility for any changes that may occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. It may not contain sufficient information for the purposes of other parties or other users. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing and other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. Where borehole logs are provided they indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of the site, as constrained by the project budget limitations. The behaviour of groundwater is complex. Our conclusions are based upon the analytical data presented in this report and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, AGE must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

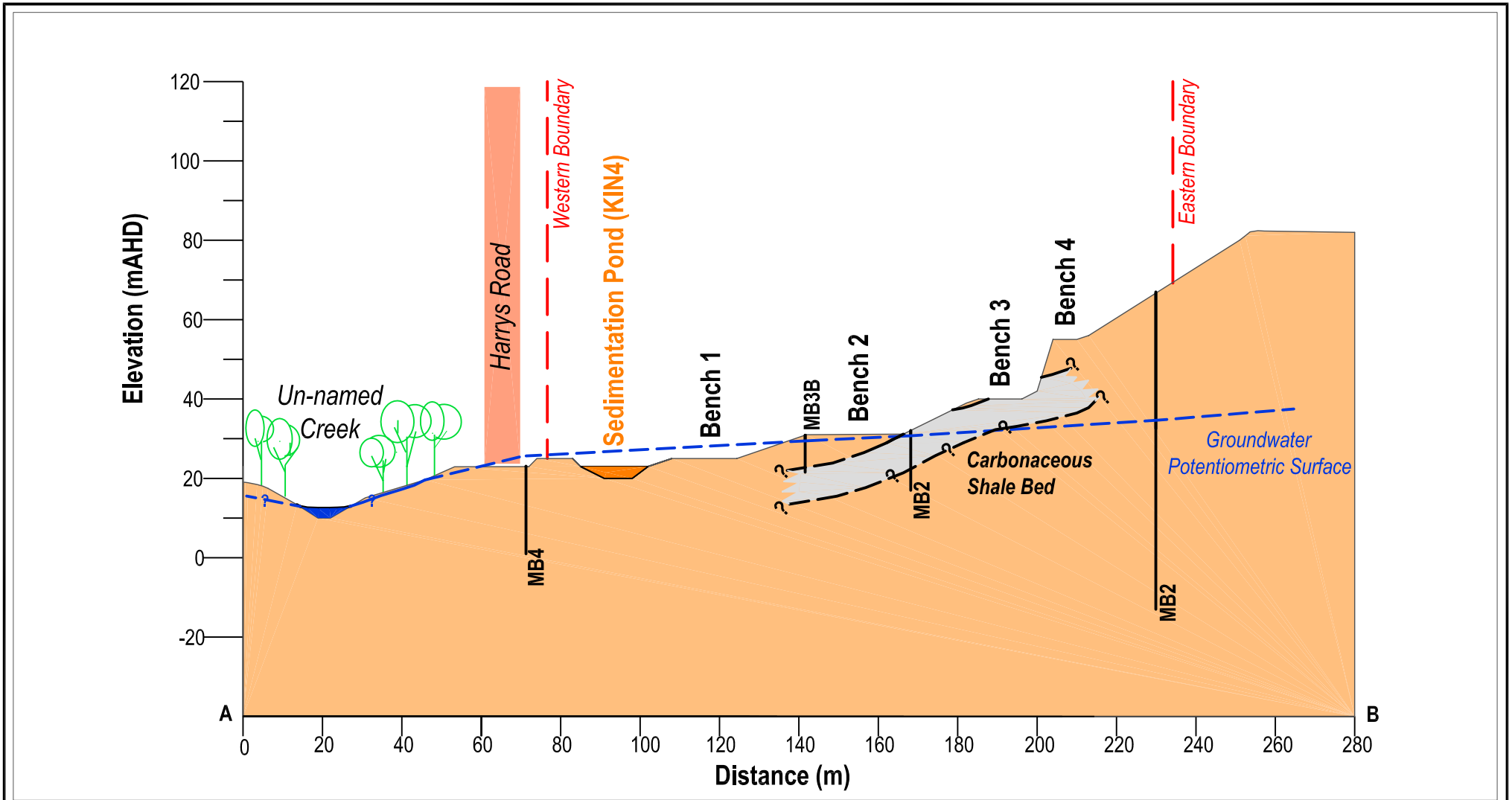
Whilst to the best of our knowledge, information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.



AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: KINNEARS QUARRY
ACID ROCK DRAINAGE GROUNDWATER ASSESSMENT
SITE LAYOUT SHOWING MONITORING LOCATIONS

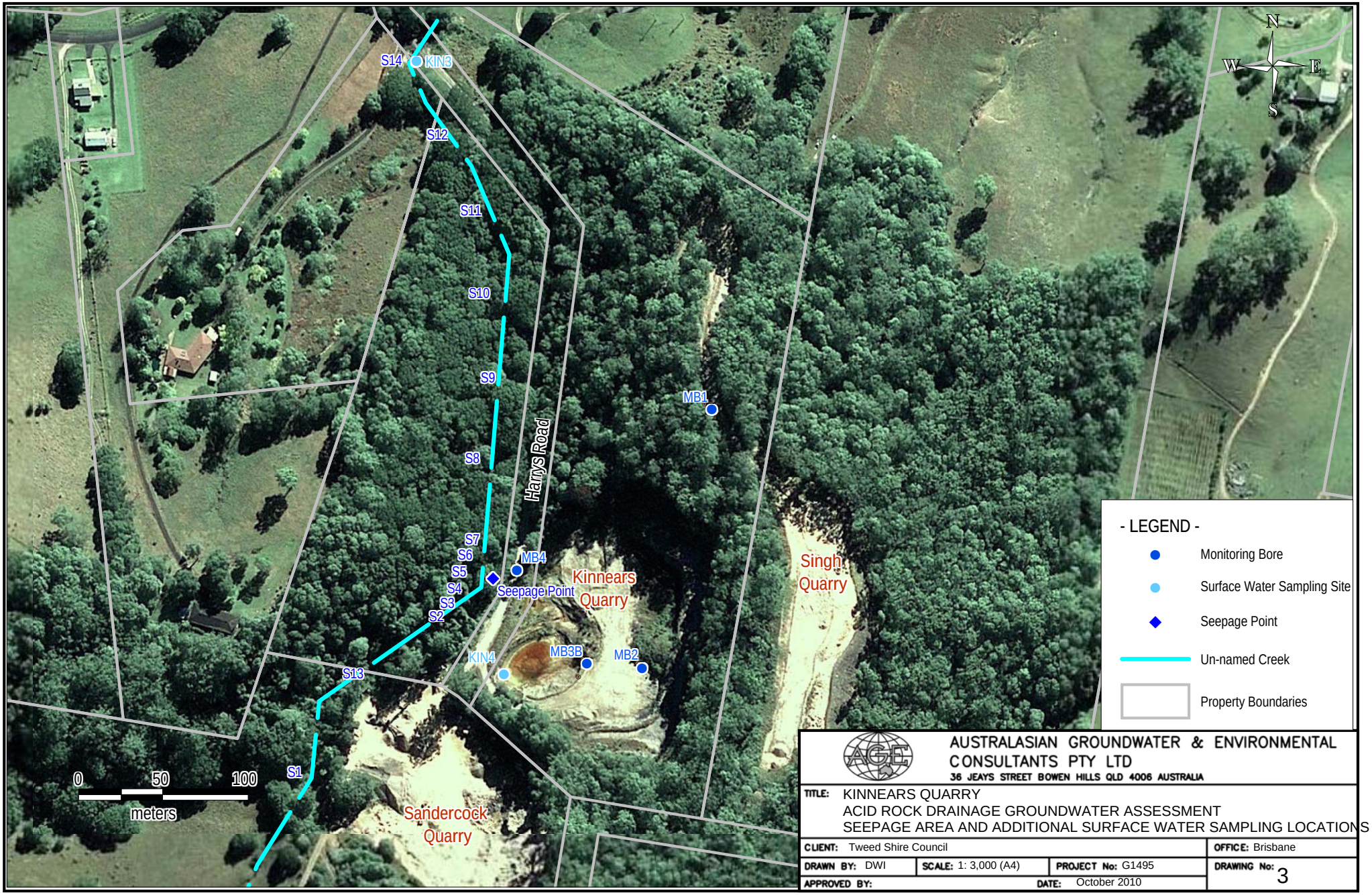
CLIENT: Tweed Shire Council			OFFICE: Brisbane
DRAWN BY: CJ	SCALE: 1: 3,000 (A4)	PROJECT No: G1495	DRAWING No: 1
APPROVED BY:		DATE: October 2010	



AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: KINNEARS QUARRY
ACID ROCK DRAINAGE GROUNDWATER ASSESSMENT
EAST - WEST CROSS SECTION

CLIENT: Tweed Shire Council			OFFICE: Brisbane
DRAWN BY: CJ	SCALE: As Shown	PROJECT No: G1495	DRAWING No: 2
APPROVED BY:		DATE: March 2010	



AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: KINNEARS QUARRY
ACID ROCK DRAINAGE GROUNDWATER ASSESSMENT
SEEPAGE AREA AND ADDITIONAL SURFACE WATER SAMPLING LOCATIONS

CLIENT: Tweed Shire Council			OFFICE: Brisbane
DRAWN BY: DWI	SCALE: 1: 3,000 (A4)	PROJECT No: G1495	DRAWING No: 3
APPROVED BY:		DATE: October 2010	

Appendix A

BOREHOLE LOGS

Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **MB1** Page 1 of 1

PROJECT NO.	G1495	DRILLER:	Mick Willox	DATUM:	MGA94 Zone56
PROJECT NAME:	Kinnears Quarry	DRILLING METHOD:		GROUND LEVEL:	67.85
DATE:	27/01/2010	DRILL RIG:	Rapid Fire 150	TOP OF CASING LEVEL:	68.48
CONTRACTOR:	Universal Drilling	COORDINATES:	533046.16E / 6867181.76N	LOGGED BY:	DWI

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 / 65		QUARTZITE: SILTSTONE highly to moderately weathered, white to grey with brown to redbrown staining, hard, dry. Siltstone content between 10% and 30%.			Grout
5 / 60		QUARTZITE: highly to moderately weathered, white to grey, hard, dry to slightly moist (at 9m). Siltstone content between 10% and 30%.			
10 / 55		SILTSTONE: highly to moderately weathered, red brown to brown, soft to medium strength, dry to slightly moist. Minor (<10%) quartzite content.			Hole Diameter 95mm
15 / 50					
20 / 45		PHYLLITE: highly to moderately weathered, buff to light red brown, soft, dry to slightly moist. Minor (<10%) quartzite content.			
25 / 40					
30 / 35		SILTSTONE: PHYLLITE highly weathered to fresh, grey to grey brown with some red brown staining, medium strength, dry to slightly moist. Minor (<10%) quartzite content. Becoming moderately to slightly weathered at 36m. Becoming slightly weathered to fresh at 39m.	▼		
35 / 30					Bentonite pellets
40 / 25		SILTSTONE: QUARTZITE slightly weathered to fresh, grey to white, medium strength to hard, dry to slightly moist.			
45 / 20		SILTSTONE: PHYLLITE fresh, light grey to grey, medium strength to hard, dry to slightly moist.			
50 / 15		SILTSTONE: fresh, dark grey, medium strength to hard, slightly moist to dry. Minor (<10%) quarzite content.			Gravel
55 / 10		QUARTZITE: SILTSTONE fresh, light grey to dark grey, medium strength to hard, slightly moist to dry. Approximately 60% quartzite/40% siltstone from 46m, and 70% siltstone/30% quartzite from 47m.			
60 / 5		QUARTZITE: fresh, light grey to white, hard, dry to slightly moist.			
65 / 0		SILTSTONE: QUARTZITE fresh, light grey to dark grey, medium strength to hard, slightly moist to dry. Approximately 60% siltstone/40% quartzite.			
70 / -5		QUARTZITE: fresh, light grey to white, hard, dry to slightly moist.			50mm PVC casing
75 / -10		SILTSTONE: QUARTZITE fresh, light grey to dark grey, medium strength to hard, slightly moist to dry. Approximately 60% siltstone/40% quartzite.			
80		SILTSTONE: fresh, light grey to dark grey, medium strength to hard, slightly moist to dry. Minor (<10%) quartzite content.			

Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **MB2**

PROJECT NO.	G1495	DRILLER:	Mick Willox	DATUM:	MGA94 Zone56
PROJECT NAME:	Kinnears Quarry	DRILLING METHOD:		GROUND LEVEL:	32.37
DATE:	27/01/2010	DRILL RIG:	Rapid Fire 150	TOP OF CASING LEVEL:	33.07
CONTRACTOR:	Universal Drilling	COORDINATES:	533005.37E / 6867027.10N	LOGGED BY:	DWI

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0		SILTSTONE: QUARTZITE slightly weathered to fresh, black to dark grey with brown limonite staining along fracture surfaces, hard, dry. Approximately 20% quartzite content.	▼		
30		QUARTZITE: SILTSTONE slightly weathered to fresh, grey to dark grey, hard, dry. Approximately 60% quartzite/40% siltstone. Fresh from 4m.			Grout
5					
		QUARTZITE: fresh, light grey to grey, hard, dry wet (moist returns at 12m, wet from 13m).			Bentonite pellets
25					
10					Gravel
20					50mm PVC casing
15					Hole Diameter 95mm
15					
20					

Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **MB3A**

PROJECT NO.	G1495	DRILLER:	Mick Willox	DATUM:	WGA84
PROJECT NAME:	Kinnears Quarry	DRILLING METHOD:		GROUND LEVEL:	31.4m
DATE:	27/01/2010	DRILL RIG:	Rapid Fire 150	TOP OF CASING LEVEL:	
CONTRACTOR:	Universal Drilling	COORDINATES:	532970E / 6867019N	LOGGED BY:	DWI

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 / 30		SILTSTONE: QUARTZITE slightly weathered to fresh, black to dark grey with brown limonite staining along fracture surfaces, hard, dry. Approximately 30% quartzite content.			Hole Collapsed
5 / 25		QUARTZITE: slightly weathered to fresh, light grey to dark grey with brown limonite staining along fracture surfaces, hard, moist to wet (wet from 4m).			
10 / 20		CARBONACEOUS SHALE: fresh, black to dark grey/grey, moderate strength to hard, moist to wet. Increasing quartzite content with depth - 80% carbonaceous shale/20% quartzite at 9m; 60% quartzite/40% carbonaceous shale at 10m.			
15 / 15					
20					

Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **MB3B**

PROJECT NO.	G1495	DRILLER:	Mick Willox	DATUM:	MGA94 Zone56
PROJECT NAME:	Kinnears Quarry	DRILLING METHOD:		GROUND LEVEL:	31.41
DATE:	28/01/2010	DRILL RIG:	Rapid Fire 150	TOP OF CASING LEVEL:	32.15
CONTRACTOR:	Universal Drilling	COORDINATES:	532972.81E / 6867029.69N	LOGGED BY:	DWI

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0		QUARTZITE: moderately weathered to fresh, light grey to dark grey with brown limonite staining along fracture surfaces, hard, dry to wet (wet from 3m). Moderately to slightly weathered at 2m. Slightly weathered to fresh at 3m.	▼	Grout Bentonite pellets	
5		SILTSTONE: QUARTZITE slightly weathered to fresh, black to dark grey, hard, wet. Approximately 60% siltstone/40% quartzite content. Fresh from 6m.		Gravel	
10		QUARTZITE: fresh, light grey to dark grey, hard, wet.		50mm PVC Casing	
15		QUARTZITE: CARBONACEOUS SHALE fresh, light grey the black/dark grey, moderate strength to hard, wet. Aproximately 50% quartzite/50% carbonaceous shale & siltstone.			
20					

Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

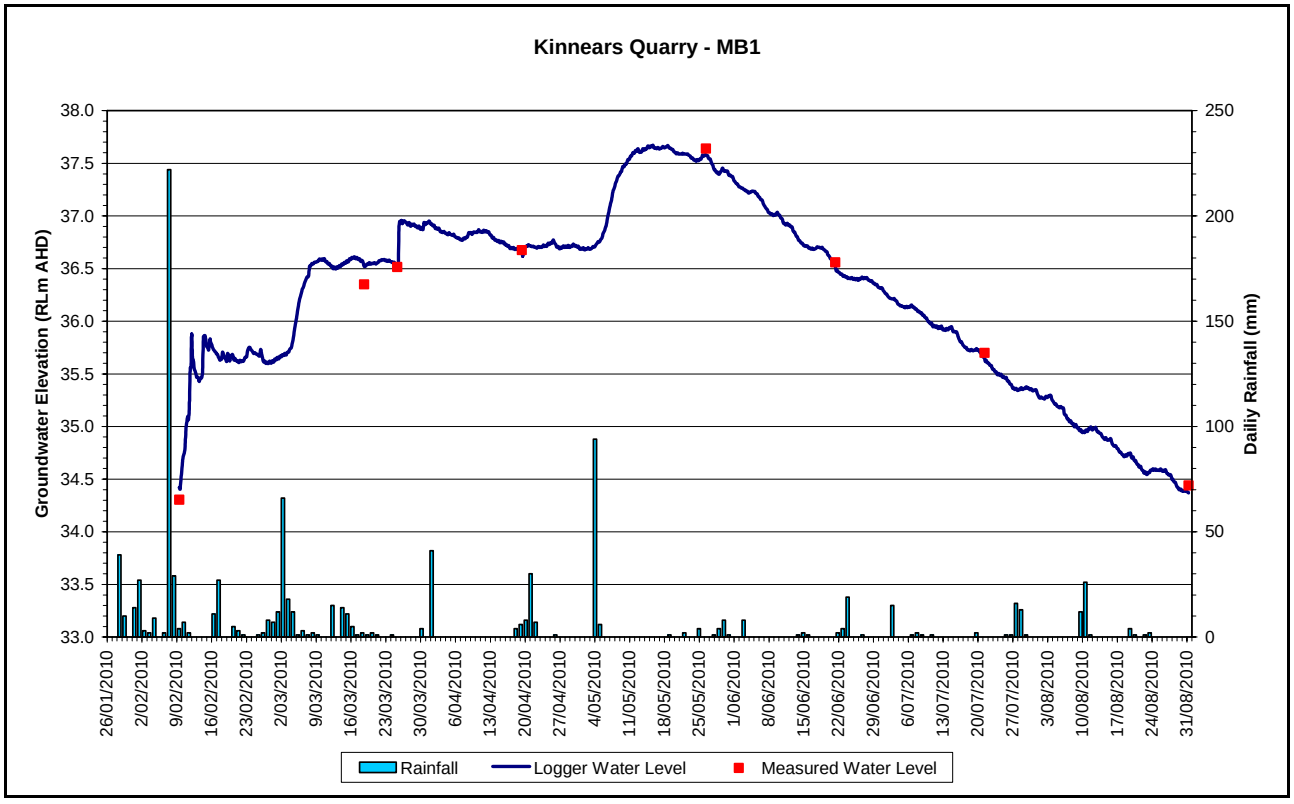
BOREHOLE ID: **MB4**

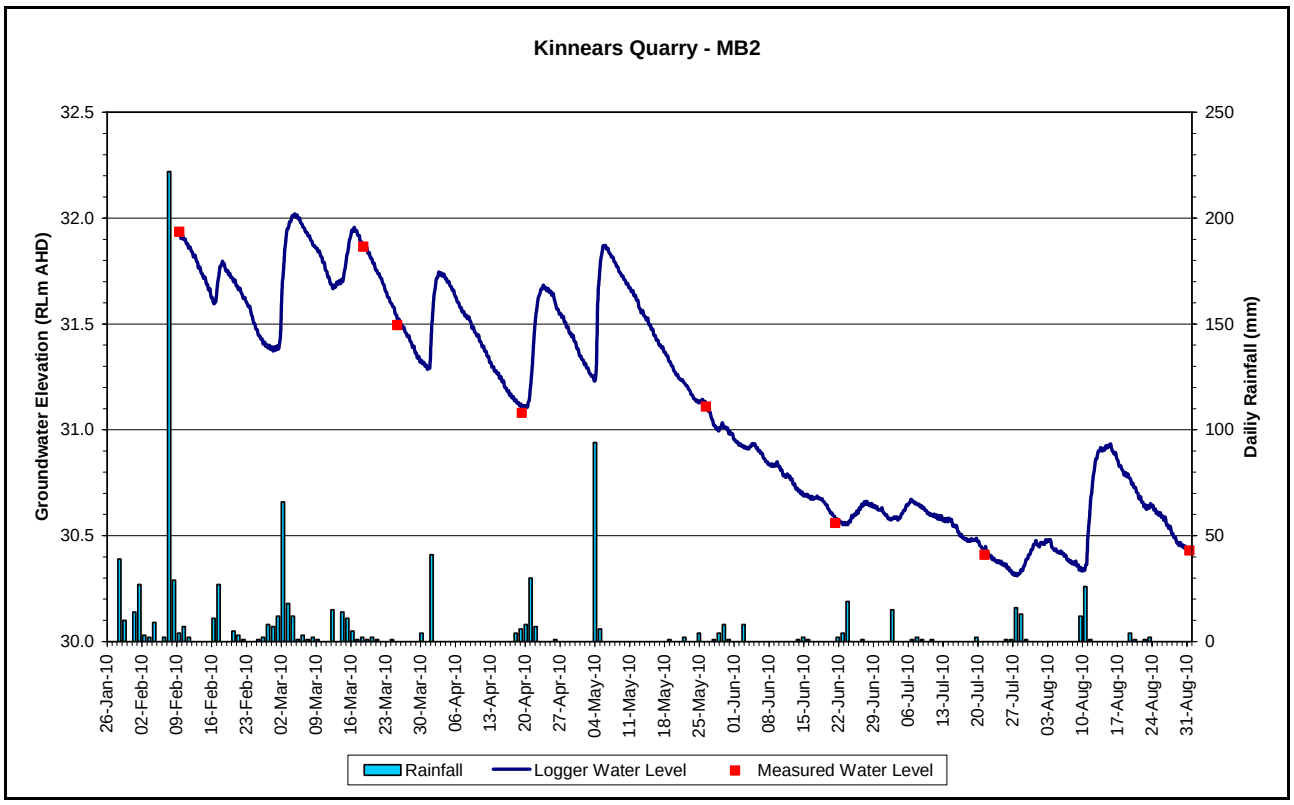
PROJECT NO.	G1495	DRILLER:	Mick Willox	DATUM:	MGA94 Zone56
PROJECT NAME:	Kinnears Quarry	DRILLING METHOD:		GROUND LEVEL:	21.90
DATE:	28/01/2010	DRILL RIG:	Rapid Fire 150	TOP OF CASING LEVEL:	22.60
CONTRACTOR:	Universal Drilling	COORDINATES:	532931.25E / 6867085.57N	LOGGED BY:	DWI

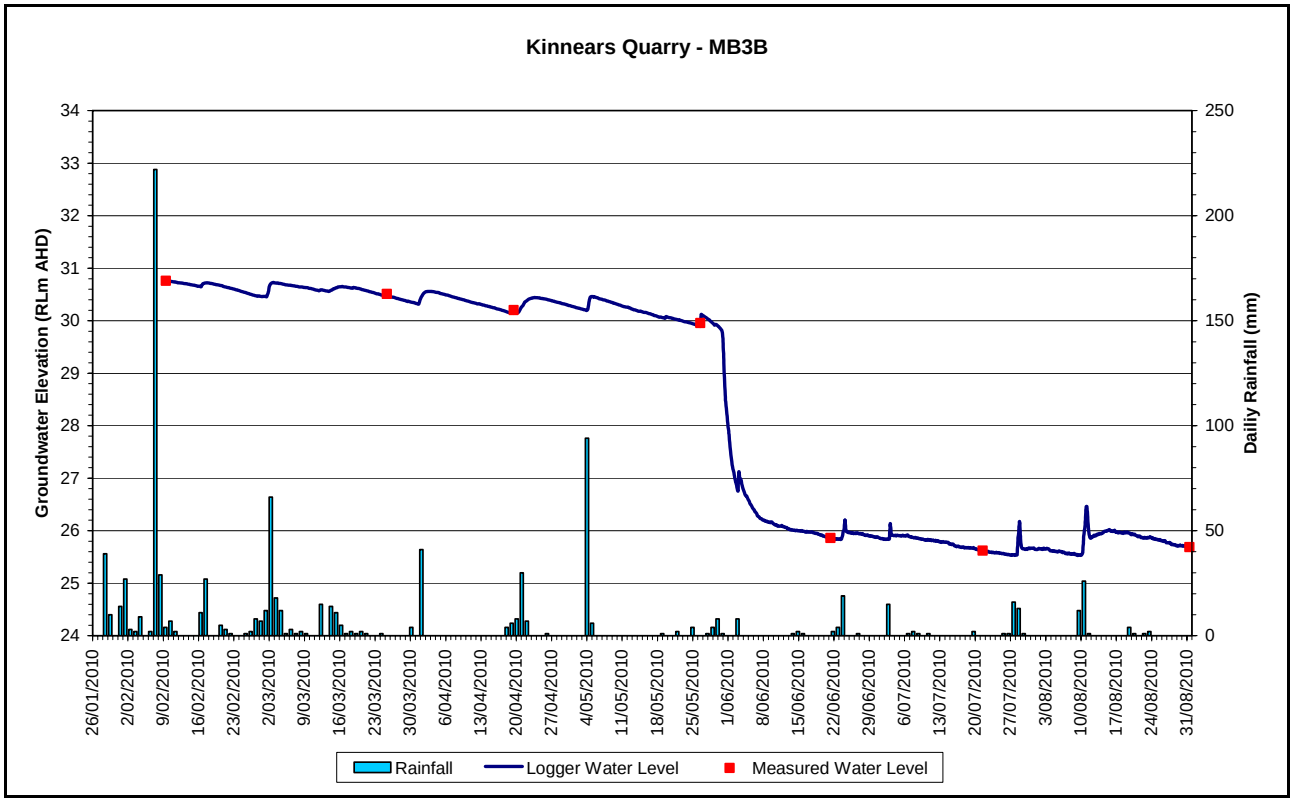
Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 / 20		SILTSTONE: QUARTZITE highly weathered to fresh, grey brown to pale brown with brown limonite staining along fracture surfaces, medium strength to hard, dry to slightly moist. Highly to moderately weathered to 3m. Moderately to slightly weathered to 5m. Slightly weathered to fresh to 6m. Fresh from 7m.			
5 / 15		QUARTZITE: fresh, white to light grey, hard, dry to slightly moist.			Grout
10 / 10		SILTSTONE: QUARTZITE fresh, dark grey to light grey, hard, dry to wet. Damp returns at 12m - groundwater inflow from 13m. Approximately 60% siltstone/40% quartzite from 11m, becoming 50% siltstone/50% quartzite from 16m, and 80% quartzite/20% siltstone from 18m.			Bentonite pellets
15 / 5					Gravel
20 / 0		QUARTZITE: fresh, light grey to white, hard, wet.			50mm PVC casing
25 / -5					
30					

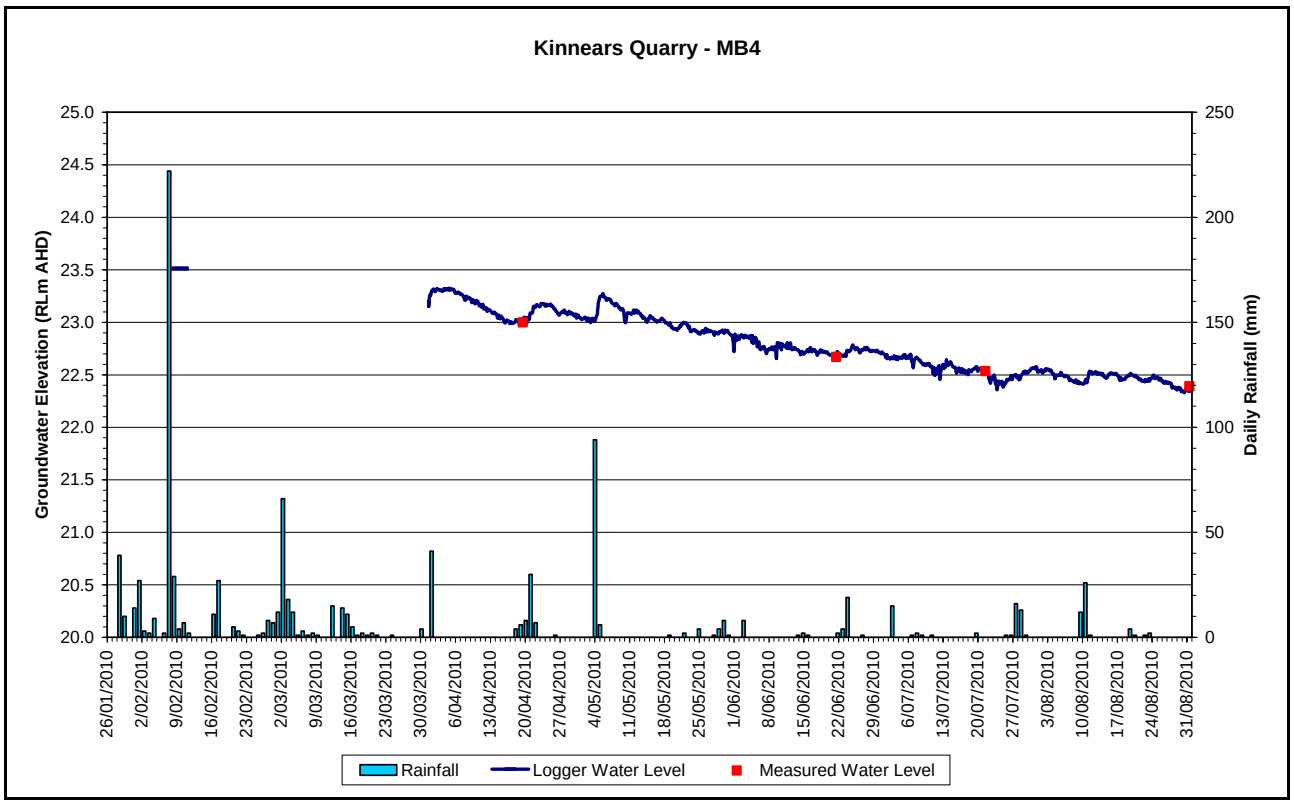
Appendix B

MONITORING BORE HYDROGRAPHS


Kinnears Quarry - MB1
Groundwater Elevation (RLm AHD)
Dailiy Rainfall (mm)
38.0
37.5
37.0
36.5
36.0
35.5
35.0
34.5
34.0
33.5
33.0
250
200
150
100
50
0
26/01/2010
2/02/2010
9/02/2010
16/02/2010
23/02/2010
2/03/2010
9/03/2010
16/03/2010
23/03/2010
30/03/2010
6/04/2010
13/04/2010
20/04/2010
27/04/2010
4/05/2010
11/05/2010
18/05/2010
25/05/2010
1/06/2010
8/06/2010
15/06/2010
22/06/2010
29/06/2010
6/07/2010
13/07/2010
20/07/2010
27/07/2010
3/08/2010
10/08/2010
17/08/2010
24/08/2010
31/08/2010
Rainfall
Logger Water Level
Measured Water Level


Kinnears Quarry - MB2
Groundwater Elevation (RLm AHD)
Dailiy Rainfall (mm)
32.5
32.0
31.5
31.0
30.5
30.0
250
200
150
100
50
0
26-Jan-10
02-Feb-10
09-Feb-10
16-Feb-10
23-Feb-10
02-Mar-10
09-Mar-10
16-Mar-10
23-Mar-10
30-Mar-10
06-Apr-10
13-Apr-10
20-Apr-10
27-Apr-10
04-May-10
11-May-10
18-May-10
25-May-10
01-Jun-10
08-Jun-10
15-Jun-10
22-Jun-10
29-Jun-10
06-Jul-10
13-Jul-10
20-Jul-10
27-Jul-10
03-Aug-10
10-Aug-10
17-Aug-10
24-Aug-10
31-Aug-10
Rainfall
Logger Water Level
Measured Water Level


Kinnears Quarry - MB3B
Groundwater Elevation (RLm AHD)
Dailiy Rainfall (mm)
34
33
32
31
30
29
28
27
26
25
24
250
200
150
100
50
0
26/01/2010
2/02/2010
9/02/2010
16/02/2010
23/02/2010
2/03/2010
9/03/2010
16/03/2010
23/03/2010
30/03/2010
6/04/2010
13/04/2010
20/04/2010
27/04/2010
4/05/2010
11/05/2010
18/05/2010
25/05/2010
1/06/2010
8/06/2010
15/06/2010
22/06/2010
29/06/2010
6/07/2010
13/07/2010
20/07/2010
27/07/2010
3/08/2010
10/08/2010
17/08/2010
24/08/2010
31/08/2010
Rainfall
Logger Water Level
Measured Water Level


Kinnears Quarry - MB4
Groundwater Elevation (RLm AHD)
Dailiy Rainfall (mm)
25.0
24.5
24.0
23.5
23.0
22.5
22.0
21.5
21.0
20.5
20.0
250
200
150
100
50
0
26/01/2010
2/02/2010
9/02/2010
16/02/2010
23/02/2010
2/03/2010
9/03/2010
16/03/2010
23/03/2010
30/03/2010
6/04/2010
13/04/2010
20/04/2010
27/04/2010
4/05/2010
11/05/2010
18/05/2010
25/05/2010
1/06/2010
8/06/2010
15/06/2010
22/06/2010
29/06/2010
6/07/2010
13/07/2010
20/07/2010
27/07/2010
3/08/2010
10/08/2010
17/08/2010
24/08/2010
31/08/2010
Rainfall
Logger Water Level
Measured Water Level

Appendix C

LABORATORY ANALYSIS CERTIFICATES

Tweed Laboratory Centre, 46 Enterprise Avenue, Tweed Heads South NSW 2486 Australia
Phone: (07) 5569 3103 Fax: (07) 5524 2676 ABN: 90 178 732 496
(All Correspondence: Tweed Shire Council PO BOX 816 Murwillumbah NSW 2484)
www.tweedlab.com.au

FINAL CERTIFICATE OF ANALYSIS

Client: Works Unit (Quarries)
Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Lims1 Report No: 10/0355-C
Attention: Athol Kiem
Client Reference:
Copy To: IK, DH & Age Consultants
Date of Report: 22/02/2010

Taken By:	Client	**No of Samples:**	6
Date Taken:	9/02/2010	**Date Testing Commenced:**	10/02/2010
Date Received:	10/02/2010	**Date Testing Completed:**	22/02/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample/Site No	Sample/Site Description
1	MB1
2	MB2
3	MB3B
4	MB4
5	KIN4
6	KIN3

COMMENTS:

Results refer to samples as received at the Laboratory.
* Tests not covered by NATA accreditation.
NP = Not Present.

NATA ACCREDITED FOR TECHNICAL COMPETENCE

This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025.
Accreditation No: 12754 & 13538

Dr Paul J Wright
(Laboratory Coordinator)
paulw@tweedlab.com.au

Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/0355-C
Date Testing Completed: 22/02/2010
Date of Report: 22/02/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			MB1	MB2	MB3B	MB4	KIN4
Date Taken:			9/02/2010	9/02/2010	9/02/2010	9/02/2010	9/02/2010
Date Received:			10/02/2010	10/02/2010	10/02/2010	10/02/2010	10/02/2010
Date Testing Commenced:			10/02/2010	10/02/2010	10/02/2010	10/02/2010	10/02/2010
Test	Method	Units	10/0355-C-1	10/0355-C-2	10/0355-C-3	10/0355-C-4	10/0355-C-5
pH	P1	pH units	6.8	5.9	5.5	6.7	2.8
Conductivity	P2	μScm^{-1}	424	1,384	1,757	1,351	1,671
Alkalinity as $CaCO_3$	C10	mg/L	120	38	39	220	NP
Carbonate (CO3)	C10	mg/L	NP	NP	NP	NP	NP
Bicarbonate HCO_3	C10	mg/L	73	23	24	134	NP
Chloride	C20	mg/L	55	22	7	24	4
Sulphur as Sulphate	M8	mg/L	6.3	608.0	842.0	471.0	628.0
Calcium	M8	mg/L	21.0	138.0	121.0	150.0	110.0
Magnesium	M8	mg/L	14.0	28.0	112.0	64.0	38.0
Sodium	M8	mg/L	40.0	106.0	10.0	23.0	11.0
Potassium M8	M8	mg/L	<5.0	9.0	<5.0	<5.0	6.0
Aluminium (Total)	M8	mg/L	4.94	25.00	7.13	16.00	13.00
Aluminium (Soluble)	M8	mg/L	0.02	0.80	4.71	0.05	12.00
Cadmium (Total)	M7	mg/L	<0.001	0.009	0.008	<0.001	0.005
Cadmium (Soluble)	M7	mg/L	<0.001	0.009	0.008	<0.001	0.005
Copper (Total)	M8	mg/L	0.03	0.64	0.52	0.09	0.88
Copper (Soluble)	M8	mg/L	<0.01	0.17	0.29	<0.01	0.81
Iron (Total)	M8	mg/L	11.0	78.0	89.0	38.0	30.0
Iron (Soluble)	M8	mg/L	0.04	13.0	83.0	18.0	27.0
Manganese (Total)	M8	mg/L	6.89	19.00	50.00	7.55	20.00
Manganese (Soluble)	M8	mg/L	6.57	15.00	47.00	7.11	18.00

Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/0355-C
Date Testing Completed: 22/02/2010
Date of Report: 22/02/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			KIN3
Date Taken:			9/02/2010
Date Received:			10/02/2010
Date Testing Commenced:			10/02/2010
Test	Method	Units	10/0355-C-6
pH	P1	pH units	3.7
Conductivity	P2	μScm^{-1}	348
Alkalinity as $CaCO_3$	C10	mg/L	NP
Carbonate (CO3)	C10	mg/L	NP
Bicarbonate HCO_3	C10	mg/L	NP
Chloride	C20	mg/L	9
Sulphur as Sulphate	M8	mg/L	94.0
Calcium	M8	mg/L	12.0
Magnesium	M8	mg/L	6.8
Sodium	M8	mg/L	9.0
Potassium M8	M8	mg/L	<5.0
Aluminium (Total)	M8	mg/L	3.50
Aluminium (Soluble)	M8	mg/L	3.27
Cadmium (Total)	M7	mg/L	0.001
Cadmium (Soluble)	M7	mg/L	0.001
Copper (Total)	M8	mg/L	0.59
Copper (Soluble)	M8	mg/L	0.54
Iron (Total)	M8	mg/L	2.21
Iron (Soluble)	M8	mg/L	1.84
Manganese (Total)	M8	mg/L	4.28
Manganese (Soluble)	M8	mg/L	4.10

Tweed Laboratory Centre, 46 Enterprise Avenue, Tweed Heads South NSW 2486 Australia
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www.tweedlab.com.au

FINAL CERTIFICATE OF ANALYSIS

Client: Works Unit (Quarries)
Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Lims1 Report No: 10/0758-C
Attention: Athol Kiem
Client Reference:
Copy To: I Kite, D Hannah + Age Consult
Date of Report: 6/04/2010

All pages of this Report have been checked and approved.

Taken By: Client
Date Taken: 25/03/2010
Date Received: 25/03/2010
No of Samples: 6
Date Testing Commenced: 25/03/2010
Date Testing Completed: 6/04/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample/Site No	Sample/Site Description
1	MB1
2	MB2
3	MB3B
4	MB4
5	KINN3
6	KINN4

COMMENTS:

Results refer to samples as received at the Laboratory.
* Tests not covered by NATA accreditation.
NP = Not Present.

NATA ACCREDITED FOR TECHNICAL COMPETENCE

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Accreditation No: 12754 & 13538

Dr Paul J Wright
(Laboratory Coordinator)
paulw@tweedlab.com.au

Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484
Attention: Athol Kiem

Lims1 Report No: 10/0758-C
Date Testing Completed: 6/04/2010
Date of Report: 6/04/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			MB1	MB2	MB3B	MB4	KINN3
Date Taken:			25/03/2010	25/03/2010	25/03/2010	25/03/2010	25/03/2010
Date Received:			25/03/2010	25/03/2010	25/03/2010	25/03/2010	25/03/2010
Date Testing Commenced:			25/03/2010	25/03/2010	25/03/2010	25/03/2010	25/03/2010
Test	Method	Units	10/0758-C-1	10/0758-C-2	10/0758-C-3	10/0758-C-4	10/0758-C-5
pH	P1	pH units	7.1	6.2	5.3	6.6	3.6
Conductivity	P2	μScm^{-1}	562	658	1,965	1,386	401
Alkalinity as $CaCO_3$	C10	mg/L	230	80	28	210	NP
Carbonate (CO3)	C10	mg/L	NP	NP	NP	NP	NP
Bicarbonate HCO_3	C10	mg/L	142	49	17	128	NP
Chloride by IC	C35	mg/L	59	39	9	25	14
Sulphur as Sulphate	M8	mg/L	3.8	167.0	1,006.0	506.0	113.0
Calcium	M8	mg/L	26.0	43.0	125.0	163.0	14.0
Magnesium	M8	mg/L	11.0	22.0	71.0	65.0	7.5
Sodium	M8	mg/L	26.0	18.0	9.5	23.0	11.0
Potassium M8	M8	mg/L	<5.0	<5.0	<5.0	<5.0	<5.0
Aluminium (Total)	M8	mg/L	6.27	1.70	6.25	24.00	3.69
Aluminium (Soluble)	M8	mg/L	0.03	0.03	4.16	0.03	3.52
Cadmium (Total)	M7	mg/L	<0.001	0.001	0.012	<0.001	0.001
Cadmium (Soluble)	M7	mg/L	<0.001	0.001	0.012	<0.001	0.001
Copper (Total)	M8	mg/L	0.14	0.12	0.81	0.19	0.47
Copper (Soluble)	M8	mg/L	<0.01	<0.01	0.17	<0.01	0.36
Iron (Total)	M8	mg/L	15.00	28.00	192.00	42.00	2.07
Iron (Soluble)	M8	mg/L	0.87	23.0	172.0	13.0	1.10
Manganese (Total)	M8	mg/L	4.88	9.95	52.00	7.64	5.98
Manganese (Soluble)	M8	mg/L	4.53	9.28	48.00	5.75	5.87

Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/0758-C
Date Testing Completed: 6/04/2010
Date of Report: 6/04/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			KINN4
Date Taken:			25/03/2010
Date Received:			25/03/2010
Date Testing Commenced:			25/03/2010
Test	Method	Units	10/0758-C-6
pH	P1	pH units	2.6
Conductivity	P2	μScm^{-1}	2,458
Alkalinity as $CaCO_3$	C10	mg/L	NP
Carbonate (CO3)	C10	mg/L	NP
Bicarbonate HCO_3	C10	mg/L	NP
Chloride by IC	C35	mg/L	9
Sulphur as Sulphate	M8	mg/L	1,096.0
Calcium	M8	mg/L	151.0
Magnesium	M8	mg/L	58.0
Sodium	M8	mg/L	8.3
Potassium M8	M8	mg/L	<5.0
Aluminium (Total)	M8	mg/L	9.95
Aluminium (Soluble)	M8	mg/L	9.71
Cadmium (Total)	M7	mg/L	0.007
Cadmium (Soluble)	M7	mg/L	0.007
Copper (Total)	M8	mg/L	0.33
Copper (Soluble)	M8	mg/L	0.24
Iron (Total)	M8	mg/L	94.00
Iron (Soluble)	M8	mg/L	93.0
Manganese (Total)	M8	mg/L	39.00
Manganese (Soluble)	M8	mg/L	39.00

Tweed Laboratory Centre, 46 Enterprise Avenue, Tweed Heads South NSW 2486 Australia
Phone: (07) 5569 3103 Fax: (07) 5524 2676 ABN: 90 178 732 496
(All Correspondence: Tweed Shire Council PO BOX 816 Murwillumbah NSW 2484)
www.tweedlab.com.au

FINAL CERTIFICATE OF ANALYSIS

Client: Works Unit (Quarries)
Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Lims1 Report No: 10/0945-C
Attention: Athol Kiem
Client Reference:
Copy To: I Kite, D Hannah + Age Consult
Date of Report: 6/05/2010

Taken By:	Client	**No of Samples:**	6
Date Taken:	19/04/2010	**Date Testing Commenced:**	19/04/2010
Date Received:	19/04/2010	**Date Testing Completed:**	6/05/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample/Site No	Sample/Site Description
1	MB1
2	MB2
3	MB3B
4	MB4
5	KINN3
6	KINN4

COMMENTS:

Results refer to samples as received at the Laboratory.
* Tests not covered by NATA accreditation.
NP = Not Present.

NATA ACCREDITED FOR TECHNICAL COMPETENCE

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Accreditation No: 12754 & 13538

Dr Paul J Wright
(Laboratory Coordinator)
paulw@tweedlab.com.au

Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/0945-C
Date Testing Completed: 6/05/2010
Date of Report: 6/05/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			MB1	MB2	MB3B	MB4	KINN3
Date Taken:			19/04/2010	19/04/2010	19/04/2010	19/04/2010	19/04/2010
Date Received:			19/04/2010	19/04/2010	19/04/2010	19/04/2010	19/04/2010
Date Testing Commenced:			19/04/2010	19/04/2010	19/04/2010	19/04/2010	19/04/2010
Test	Method	Units	10/0945-C-1	10/0945-C-2	10/0945-C-3	10/0945-C-4	10/0945-C-5
pH	P1	pH units	7.1	6.3	4.9	6.7	3.6
Conductivity	P2	μScm^{-1}	565	458	2,202	1,374	418
Alkalinity as $CaCO_3$	C10	mg/L	220	87	8	210	NP
Carbonate (CO3)	C10	mg/L	NP	NP	NP	NP	NP
Bicarbonate HCO_3	C10	mg/L	133	53	5	128	NP
Chloride by IC	C35	mg/L	72	48	48	12	17
Calcium	M8	mg/L	16.0	29.0	161.0	191.0	16.0
Magnesium	M8	mg/L	9.6	20.0	89.0	75.0	9.0
Sodium	M8	mg/L	32.0	23.0	13.0	25.0	14.0
Potassium M8	M8	mg/L	<5.0	<5.0	<5.0	<5.0	<5.0
Sulphur as Sulphate	M8	mg/L	3.0	72.0	1,382.0	597.0	131.0
Aluminium (Total)	M8	mg/L	11.00	6.34	8.39	27.00	4.45
Aluminium (Soluble)	M8	mg/L	0.04	0.01	6.71	0.02	4.12
Cadmium (Total)	M7	mg/L	0.002	<0.001	0.015	<0.001	0.001
Cadmium (Soluble)	M7	mg/L	<0.001	<0.001	0.011	<0.001	0.001
Copper (Total)	M8	mg/L	0.07	0.09	0.70	0.13	0.47
Copper (Soluble)	M8	mg/L	<0.01	<0.01	0.40	<0.01	0.41
Iron (Total)	M8	mg/L	0.22	33.00	272.00	45.00	1.60
Iron (Soluble)	M8	mg/L	0.67	20.0	253.0	17.0	0.87
Manganese (Total)	M8	mg/L	6.40	8.70	65.00	7.69	7.84
Manganese (Soluble)	M8	mg/L	5.47	7.61	60.00	6.88	7.42

Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/0945-C
Date Testing Completed: 6/05/2010
Date of Report: 6/05/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			KINN4
Date Taken:			19/04/2010
Date Received:			19/04/2010
Date Testing Commenced:			19/04/2010
Test	Method	Units	10/0945-C-6
pH	P1	pH units	2.6
Conductivity	P2	μScm^{-1}	2,418
Alkalinity as $CaCO_3$	C10	mg/L	NP
Carbonate (CO3)	C10	mg/L	NP
Bicarbonate HCO_3	C10	mg/L	NP
Chloride by IC	C35	mg/L	10
Calcium	M8	mg/L	170.0
Magnesium	M8	mg/L	72.0
Sodium	M8	mg/L	8.9
Potassium M8	M8	mg/L	<5.0
Sulphur as Sulphate	M8	mg/L	1,299.0
Aluminium (Total)	M8	mg/L	9.46
Aluminium (Soluble)	M8	mg/L	9.01
Cadmium (Total)	M7	mg/L	0.006
Cadmium (Soluble)	M7	mg/L	0.006
Copper (Total)	M8	mg/L	0.18
Copper (Soluble)	M8	mg/L	0.16
Iron (Total)	M8	mg/L	125.00
Iron (Soluble)	M8	mg/L	121.0
Manganese (Total)	M8	mg/L	50.00
Manganese (Soluble)	M8	mg/L	48.00

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FINAL CERTIFICATE OF ANALYSIS

Client: Works Unit (Quarries)
Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Lims1 Report No: 10/1291-C
Attention: Athol Kiem
Client Reference:
Copy To: I Kite, D Hannah + Age Consult
Date of Report: 9/06/2010

All pages of this Report have been checked and approved.

Taken By: Client
Date Taken: 26/05/2010
Date Received: 26/05/2010
No of Samples: 6
Date Testing Commenced: 26/05/2010
Date Testing Completed: 31/05/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample/Site No	Sample/Site Description
1	MB1
2	MB2
3	MB3B
4	MB4
5	KINN3
6	KINN4

COMMENTS:

Results refer to samples as received at the Laboratory.
* Tests not covered by NATA accreditation.
NP = Not Present.
Report reissued with correct client details.

NATA ACCREDITED FOR TECHNICAL COMPETENCE

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Accreditation No: 12754 & 13538

Dr Paul J Wright
(Laboratory Coordinator)
paulw@tweedlab.com.au

Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/1291-C
Date Testing Completed: 31/05/2010
Date of Report: 9/06/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			MB1	MB2	MB3B	MB4	KINN3
Date Taken:			26/05/2010	26/05/2010	26/05/2010	26/05/2010	26/05/2010
Date Received:			26/05/2010	26/05/2010	26/05/2010	26/05/2010	26/05/2010
Date Testing Commenced:			26/05/2010	26/05/2010	26/05/2010	26/05/2010	26/05/2010
Test	Method	Units	10/1291-C-1	10/1291-C-2	10/1291-C-3	10/1291-C-4	10/1291-C-5
pH	P1	pH units	7.0	6.2	5.3	6.6	3.6
Conductivity	P2	μScm^{-1}	614	428	2,401	1,391	377
Alkalinity as $CaCO_3$	C10	mg/L	240	93	30	210	<1
Carbonate (CO3)	C10	mg/L	NP	NP	NP	NP	NP
Bicarbonate HCO_3	C10	mg/L	147	57	18	127	<1
Chloride by IC	C35	mg/L	63	37	7	20	12
Sulphur as Sulphate	M8	mg/L	2.8	50.0	1,337.0	524.0	101.0
Calcium	M8	mg/L	11.0	21.0	169.0	169.0	11.0
Potassium M8	M8	mg/L	<5.0	<5.0	<5.0	<5.0	<5.0
Sodium	M8	mg/L	27.0	16.0	12.0	23.0	12.0
Magnesium	M8	mg/L	7.9	15.0	86.0	68.0	7.0
Aluminium (Total)	M8	mg/L	0.76	3.27	8.98	4.87	2.99
Aluminium (Soluble)	M8	mg/L	0.05	0.02	8.00	0.06	2.95
Cadmium (Total)	M7	mg/L	<0.001	<0.001	0.002	<0.001	<0.001
Cadmium (Soluble)	M7	mg/L	<0.001	<0.001	0.002	<0.001	<0.001
Copper (Total)	M8	mg/L	0.04	0.09	0.76	0.05	0.36
Copper (Soluble)	M8	mg/L	<0.01	<0.01	0.55	<0.01	0.34
Iron (Total)	M8	mg/L	2.76	18.0	247.0	19.0	1.60
Iron (Soluble)	M8	mg/L	0.74	10.0	235.0	12.0	0.58
Manganese (Total)	M8	mg/L	4.93	6.41	64.00	5.78	5.50
Manganese (Soluble)	M8	mg/L	4.75	5.76	61.00	5.11	5.50

Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/1291-C
Date Testing Completed: 31/05/2010
Date of Report: 9/06/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			KINN4
Date Taken:			26/05/2010
Date Received:			26/05/2010
Date Testing Commenced:			26/05/2010
Test	Method	Units	10/1291-C-6
pH	P1	pH units	2.8
Conductivity	P2	μScm^{-1}	1,945
Alkalinity as $CaCO_3$	C10	mg/L	<1
Carbonate (CO3)	C10	mg/L	NP
Bicarbonate HCO_3	C10	mg/L	<1
Chloride by IC	C35	mg/L	6
Sulphur as Sulphate	M8	mg/L	847.0
Calcium	M8	mg/L	132.0
Potassium M8	M8	mg/L	<5.0
Sodium	M8	mg/L	7.5
Magnesium	M8	mg/L	50.0
Aluminium (Total)	M8	mg/L	7.34
Aluminium (Soluble)	M8	mg/L	6.99
Cadmium (Total)	M7	mg/L	<0.001
Cadmium (Soluble)	M7	mg/L	<0.001
Copper (Total)	M8	mg/L	0.17
Copper (Soluble)	M8	mg/L	0.15
Iron (Total)	M8	mg/L	64.0
Iron (Soluble)	M8	mg/L	60.0
Manganese (Total)	M8	mg/L	31.00
Manganese (Soluble)	M8	mg/L	30.00

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FINAL CERTIFICATE OF ANALYSIS

Client: Works Unit (Quarries)
Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Lims1 Report No: 10/1513-C
Attention: Athol Kiem
Client Reference:
Copy To: I Kite, D Hannah + Age Consult
Date of Report: 28/06/2010

All pages of this Report have been checked and approved.

Taken By:	Client	**No of Samples:**	6
Date Taken:	21/06/2010	**Date Testing Commenced:**	21/06/2010
Date Received:	21/06/2010	**Date Testing Completed:**	28/06/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample/Site No	Sample/Site Description
1	MB1
2	MB2
3	MB3B
4	MB4
5	KINN3
6	KINN4

COMMENTS:

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* Tests not covered by NATA accreditation.
NP = Not Present.

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Accreditation No: 12754 & 13538

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Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/1513-C
Date Testing Completed: 28/06/2010
Date of Report: 28/06/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			MB1	MB2	MB3B	MB4	KINN3
Date Taken:			21/06/2010	21/06/2010	21/06/2010	21/06/2010	21/06/2010
Date Received:			21/06/2010	21/06/2010	21/06/2010	21/06/2010	21/06/2010
Date Testing Commenced:			21/06/2010	21/06/2010	21/06/2010	21/06/2010	21/06/2010
Test	Method	Units	10/1513-C-1	10/1513-C-2	10/1513-C-3	10/1513-C-4	10/1513-C-5
pH	P1	pH units	6.9	6.3	2.6	6.6	3.8
Conductivity	P2	μScm^{-1}	589	417	3,480	1,409	360
Alkalinity as $CaCO_3$	C10	mg/L	250	97	NP	220	NP
Carbonate (CO3)	C10	mg/L	NP	NP	NP	NP	NP
Bicarbonate HCO_3	C10	mg/L	155	59	NP	135	NP
Chloride by IC	C35	mg/L	78	53	11	30	21
Sulphur as Sulphate	M8	mg/L	2.8	53.0	1,495.0	520.0	113.0
Calcium	M8	mg/L	11.0	21.0	165.0	161.0	12.0
Potassium M8	M8	mg/L	<5.0	<5.0	<5.0	<5.0	<5.0
Sodium	M8	mg/L	32.0	19.0	9.0	21.0	14.0
Magnesium	M8	mg/L	8.7	18.0	124.0	64.0	7.7
Aluminium (Total)	M8	mg/L	3.47	6.00	21.00	40.00	2.63
Aluminium (Soluble)	M8	mg/L	0.07	0.02	18.00	0.07	2.63
Cadmium (Total)	M7	mg/L	<0.001	0.001	0.021	<0.001	0.001
Cadmium (Soluble)	M7	mg/L	<0.001	<0.001	0.021	<0.001	<0.001
Copper (Total)	M8	mg/L	0.02	0.10	2.95	0.17	0.24
Copper (Soluble)	M8	mg/L	<0.01	<0.01	2.27	<0.01	0.24
Iron (Total)	M8	mg/L	9.12	29.0	117.0	59.0	0.92
Iron (Soluble)	M8	mg/L	1.07	19.0	103.0	13.0	0.61
Manganese (Total)	M8	mg/L	5.57	8.11	86.00	8.27	6.39
Manganese (Soluble)	M8	mg/L	4.83	6.97	84.00	5.13	6.39

Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/1513-C
Date Testing Completed: 28/06/2010
Date of Report: 28/06/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			KINN4
Date Taken:			21/06/2010
Date Received:			21/06/2010
Date Testing Commenced:			21/06/2010
Test	Method	Units	10/1513-C-6
pH	P1	pH units	2.7
Conductivity	P2	μScm^{-1}	2,588
Alkalinity as $CaCO_3$	C10	mg/L	NP
Carbonate (CO3)	C10	mg/L	NP
Bicarbonate HCO_3	C10	mg/L	NP
Chloride by IC	C35	mg/L	13
Sulphur as Sulphate	M8	mg/L	1,209.0
Calcium	M8	mg/L	175.0
Potassium M8	M8	mg/L	<5.0
Sodium	M8	mg/L	8.6
Magnesium	M8	mg/L	66.0
Aluminium (Total)	M8	mg/L	10.00
Aluminium (Soluble)	M8	mg/L	9.33
Cadmium (Total)	M7	mg/L	0.007
Cadmium (Soluble)	M7	mg/L	0.007
Copper (Total)	M8	mg/L	0.13
Copper (Soluble)	M8	mg/L	0.12
Iron (Total)	M8	mg/L	100
Iron (Soluble)	M8	mg/L	96.0
Manganese (Total)	M8	mg/L	43.00
Manganese (Soluble)	M8	mg/L	42.00

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FINAL CERTIFICATE OF ANALYSIS

Client: Works Unit (Quarries)
Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Lims1 Report No: 10/1748-C
Attention: Athol Kiem
Client Reference:
Copy To: I Kite, D Hannah + Age Consult
Date of Report: 30/07/2010

All pages of this Report have been checked and approved.

Taken By:	Client	**No of Samples:**	6
Date Taken:	21/07/2010	**Date Testing Commenced:**	21/07/2010
Date Received:	21/07/2010	**Date Testing Completed:**	30/07/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample/Site No	Sample/Site Description
1	MB1
2	MB2
3	MB3B
4	MB4
5	KINN3
6	KINN4

COMMENTS:

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* Tests not covered by NATA accreditation.
NP = Not Present.

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Accreditation No: 12754 & 13538

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Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/1748-C
Date Testing Completed: 30/07/2010
Date of Report: 30/07/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			MB1	MB2	MB3B	MB4	KINN3
Date Taken:			21/07/2010	21/07/2010	21/07/2010	21/07/2010	21/07/2010
Date Received:			21/07/2010	21/07/2010	21/07/2010	21/07/2010	21/07/2010
Date Testing Commenced:			21/07/2010	21/07/2010	21/07/2010	21/07/2010	21/07/2010
Test	Method	Units	10/1748-C-1	10/1748-C-2	10/1748-C-3	10/1748-C-4	10/1748-C-5
pH	P1	pH units	6.4	6.3	3.5	6.5	3.7
Conductivity	P2	μScm^{-1}	396	386	2,115	1,312	343
Alkalinity as $CaCO_3$	C10	mg/L	110	94	NP	210	NP
Carbonate (CO_3)	C10	mg/L	NP	NP	NP	NP	NP
Bicarbonate HCO_3	C10	mg/L	67	57	NP	131	NP
Chloride by IC	C35	mg/L	62	43	9	24	15
Sulphur as Sulphate	M8	mg/L	1.2	57.0	1,418.0	613.0	114.0
Calcium	M8	mg/L	78.0	20.0	155.0	193.0	14.0
Potassium M8	M8	mg/L	<5.0	<5.0	<5.0	<5.0	<5.0
Sodium	M8	mg/L	32.0	19.0	11.0	26.0	15.0
Magnesium	M8	mg/L	19.0	18.0	128.0	79.0	9.0
Aluminium (Total)	M8	mg/L	0.73	3.18	9.84	17.00	2.50
Aluminium (Soluble)	M8	mg/L	0.02	0.02	8.37	0.23	2.50
Cadmium (Total)	M7	mg/L	<0.001	0.010	0.011	<0.001	0.001
Cadmium (Soluble)	M7	mg/L	<0.001	<0.001	0.011	<0.001	0.001
Copper (Total)	M8	mg/L	<0.01	0.06	0.45	0.07	0.21
Copper (Soluble)	M8	mg/L	<0.01	<0.01	0.28	<0.01	0.21
Iron (Total)	M8	mg/L	4.33	24.0	146.0	35.0	1.20
Iron (Soluble)	M8	mg/L	3.84	18.0	128.0	13.0	0.77
Manganese (Total)	M8	mg/L	4.07	7.22	78.00	7.29	7.03
Manganese (Soluble)	M8	mg/L	3.64	6.53	78.00	5.35	7.03

Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/1748-C
Date Testing Completed: 30/07/2010
Date of Report: 30/07/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			KINN4
Date Taken:			21/07/2010
Date Received:			21/07/2010
Date Testing Commenced:			21/07/2010
Test	Method	Units	10/1748-C-6
pH	P1	pH units	8.8
Conductivity	P2	μScm^{-1}	1,984
Alkalinity as $CaCO_3$	C10	mg/L	62
Carbonate (CO_3)	C10	mg/L	7
Bicarbonate HCO_3	C10	mg/L	31
Chloride by IC	C35	mg/L	10
Sulphur as Sulphate	M8	mg/L	1,417.0
Calcium	M8	mg/L	482.0
Potassium M8	M8	mg/L	<5.0
Sodium	M8	mg/L	9.8
Magnesium	M8	mg/L	67.0
Aluminium (Total)	M8	mg/L	0.08
Aluminium (Soluble)	M8	mg/L	0.03
Cadmium (Total)	M7	mg/L	<0.001
Cadmium (Soluble)	M7	mg/L	<0.001
Copper (Total)	M8	mg/L	<0.01
Copper (Soluble)	M8	mg/L	<0.01
Iron (Total)	M8	mg/L	0.41
Iron (Soluble)	M8	mg/L	0.01
Manganese (Total)	M8	mg/L	11.00
Manganese (Soluble)	M8	mg/L	8.17

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FINAL CERTIFICATE OF ANALYSIS

Client: Works Unit (Quarries)
Address: Tweed Shire Council
PO Box 816
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NSW 2484

Lims1 Report No: 10/2081-C
Attention: Athol Kiem
Client Reference:
Copy To: I Kite, D Hannah + Age Consult
Date of Report: 14/09/2010

All pages of this Report have been checked and approved.

Taken By: Client
Date Taken: 31/08/2010
Date Received: 31/08/2010
No of Samples: 6
Date Testing Commenced: 31/08/2010
Date Testing Completed: 14/09/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample/Site No	Sample/Site Description
1	MB1
2	MB2
3	MB3B
4	MB4
5	KINN3
6	KINN4

COMMENTS:

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* Tests not covered by NATA accreditation.
NP = Not Present.

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Client: Works Unit (Quarries)

Address: Tweed Shire Council
PO Box 816
MURWILLUMBAH
NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/2081-C
Date Testing Completed: 14/09/2010
Date of Report: 14/09/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			MB1	MB2	MB3B	MB4	KINN3
Date Taken:			31/08/2010	31/08/2010	31/08/2010	31/08/2010	31/08/2010
Date Received:			31/08/2010	31/08/2010	31/08/2010	31/08/2010	31/08/2010
Date Testing Commenced:			31/08/2010	31/08/2010	31/08/2010	31/08/2010	31/08/2010
Test	Method	Units	10/2081-C-1	10/2081-C-2	10/2081-C-3	10/2081-C-4	10/2081-C-5
pH	P1	pH units	6.6	6.1	3.0	6.5	3.8
Conductivity	P2	μScm^{-1}	555	450	2,014	1,378	368
Alkalinity as $CaCO_3$	C10	mg/L	200	85	<1	220	<1
Carbonate (CO_3)	C10	mg/L	NP	NP	NP	NP	NP
Bicarbonate HCO_3	C10	mg/L	122	52	<1	134	<1
Chloride by IC	C35	mg/L	64	41	9	25	15
Sulphur as Sulphate	M8	mg/L	3.0	91.0	1,083.0	638.0	132.0
Calcium	M8	mg/L	24.0	26.0	128.0	204.0	15.0
Potassium M8	M8	mg/L	<5.0	<5.0	<5.0	<5.0	<5.0
Sodium	M8	mg/L	30.0	20.0	9.2	25.0	15.0
Magnesium	M8	mg/L	10.0	17.0	111.0	78.0	9.5
Aluminium (Total)	M8	mg/L	0.46	5.78	6.77	4.01	2.78
Aluminium (Soluble)	M8	mg/L	0.05	0.12	5.67	0.09	2.77
Cadmium (Total)	M7	mg/L	<0.001	0.003	0.008	<0.001	0.001
Cadmium (Soluble)	M7	mg/L	<0.001	<0.001	0.008	<0.001	0.001
Copper (Total)	M8	mg/L	0.07	0.63	0.33	0.04	0.20
Copper (Soluble)	M8	mg/L	<0.01	<0.01	0.22	<0.01	0.16
Iron (Total)	M8	mg/L	2.69	28.0	47.0	17.0	1.94
Iron (Soluble)	M8	mg/L	1.95	23.0	31.0	12.0	1.70
Manganese (Total)	M8	mg/L	5.06	8.02	70.00	6.15	8.13
Manganese (Soluble)	M8	mg/L	5.06	7.74	69.00	5.24	8.13

Client: Works Unit (Quarries)

Address: Tweed Shire Council
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NSW 2484

Attention: Athol Kiem

Lims1 Report No: 10/2081-C
Date Testing Completed: 14/09/2010
Date of Report: 14/09/2010

Sample Description: Kinnears Quarry-AGE Bores-Water Samples-Chemical

Sample Identification:			KINN4
Date Taken:			31/08/2010
Date Received:			31/08/2010
Date Testing Commenced:			31/08/2010
Test	Method	Units	10/2081-C-6
pH	P1	pH units	3.5
Conductivity	P2	μScm^{-1}	2,092
Alkalinity as $CaCO_3$	C10	mg/L	<1
Carbonate (CO_3)	C10	mg/L	NP
Bicarbonate HCO_3	C10	mg/L	<1
Chloride by IC	C35	mg/L	11
Sulphur as Sulphate	M8	mg/L	1,371.0
Calcium	M8	mg/L	421.0
Potassium M8	M8	mg/L	5.0
Sodium	M8	mg/L	9.2
Magnesium	M8	mg/L	59.0
Aluminium (Total)	M8	mg/L	3.04
Aluminium (Soluble)	M8	mg/L	3.04
Cadmium (Total)	M7	mg/L	0.003
Cadmium (Soluble)	M7	mg/L	0.002
Copper (Total)	M8	mg/L	0.03
Copper (Soluble)	M8	mg/L	<0.01
Iron (Total)	M8	mg/L	4.84
Iron (Soluble)	M8	mg/L	4.55
Manganese (Total)	M8	mg/L	33.00
Manganese (Soluble)	M8	mg/L	32.00

Appendix D

WATER QUALITY MONITORING RESULTS

Groundwater Samples - MB1

Analyte	Units	LOR	9/02/2010	25/03/2010	19/04/2010	26/05/2010	21/06/2010	21/07/2010	31/08/2010
pH Lab	pH units	<0.1	6.8	7.1	7.1	7	6.9	6.4	6.6
pH Field	pH units		7.26	6.58	6.47	6.38	6.73	6.42	6.77
EC Lab	μScm^{-1}	<1	424	562	565	614	589	396	555
EC Field	μScm^{-1}		438	601	614	642	658	637	675
Dissolved Oxygen	mg/L		3.29	0.27	0.64	0.35	0.8	0.27	0.26
Alkalinity as $CaCO_3$	mg/L	<1	120	230	220	240	250	110	200
Carbonate (CO_3)	mg/L	<1	NP	NP	NP	NP	NP	NP	NP
Bicarbonate HCO_3	mg/L	<1	73	142	133	147	155	67	122
Chloride	mg/L	<3	55	59	72	63	78	62	64
Sulphur as Sulphate	mg/L	<0.1	6.3	3.8	3	2.8	2.8	1.2	3
Calcium	mg/L	<0.1	21	26	16	11	11	78	24
Magnesium	mg/L	<0.1	14	11	9.6	<5	8.7	19	10
Sodium	mg/L	<0.1	40	26	32	27	32	32	30
Potassium M8	mg/L	<5	<5	<5	<5	7.9	<5	<5	<5
Aluminium (Total)	mg/L	<0.01	4.94	6.27	11	0.76	3.47	0.73	0.46
Aluminium (Soluble)	mg/L	<0.01	0.02	0.03	0.04	0.05	0.07	0.02	0.05
Cadmium (Total)	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Cadmium (Soluble)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Total)	mg/L	<0.01	0.03	0.14	0.07	0.04	0.02	<0.01	0.07
Copper (Soluble)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron (Total)	mg/L	<0.01	11	15	0.22	2.76	9.12	4.33	2.69
Iron (Soluble)	mg/L	<0.01	0.04	0.87	0.67	0.74	1.07	3.84	1.95
Manganese (Total)	mg/L	<0.01	6.89	4.88	6.4	4.93	5.57	4.07	5.06
Manganese (Soluble)	mg/L	<0.01	6.57	4.53	5.47	4.75	4.83	3.64	5.06

Groundwater Samples - MB2

Analyte	Units	LOR	9/02/2010	25/03/2010	19/04/2010	26/05/2010	21/06/2010	21/07/2010	31/08/2010
pH Lab	pH units	<0.1	5.9	6.2	6.3	6.2	6.3	6.3	6.1
pH Field	pH units		6.86	5.78	5.78	5.63	5.64	5.79	5.9
EC Lab	μScm^{-1}	<1	1384	658	458	428	417	386	450
EC Field	μScm^{-1}		509	654	519	425	414	387	520
Dissolved Oxygen	mg/L		0.26	0.15	0.22	0.32	0.26	0.18	0.23
Alkalinity as $CaCO_3$	mg/L	<1	38	80	87	93	97	94	85
Carbonate (CO_3)	mg/L	<1	NP	NP	NP	NP	NP	NP	NP
Bicarbonate HCO_3	mg/L	<1	23	49	53	57	59	57	52
Chloride	mg/L	<3	22	39	48	37	53	43	41
Sulphur as Sulphate	mg/L	<0.1	608	167	72	50	53	57	91
Calcium	mg/L	<0.1	138	43	29	21	21	20	26
Magnesium	mg/L	<0.1	28	22	20	<5	18	18	17
Sodium	mg/L	<0.1	106	18	23	16	19	19	20
Potassium M8	mg/L	<5	9	<5	<5	15	<5	<5	<5
Aluminium (Total)	mg/L	<0.01	25	1.7	6.34	3.27	6	3.18	5.78
Aluminium (Soluble)	mg/L	<0.01	0.8	0.03	0.01	0.02	0.02	0.02	0.12
Cadmium (Total)	mg/L	<0.001	0.009	0.001	<0.001	<0.001	0.001	0.01	0.003
Cadmium (Soluble)	mg/L	<0.001	0.009	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Total)	mg/L	<0.01	0.64	0.12	0.09	0.09	0.1	0.06	0.63
Copper (Soluble)	mg/L	<0.01	0.17	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron (Total)	mg/L	<0.01	78	28	33	18	29	24	28
Iron (Soluble)	mg/L	<0.01	13	23	20	10	19	18	23
Manganese (Total)	mg/L	<0.01	19	9.95	8.7	6.41	8.11	7.22	8.02
Manganese (Soluble)	mg/L	<0.01	15	9.28	7.61	5.76	6.97	6.53	7.74

Groundwater Samples - MB3B

Analyte	Units	LOR	9/02/2010	25/03/2010	19/04/2010	26/05/2010	21/06/2010	21/07/2010	31/08/2010
pH Lab	pH units	<0.1	5.5	5.3	4.9	5.3	2.6	3.5	3
pH Field	pH units		6.3	5.45	5.6	5.08	2.63	3.44	2.98
EC Lab	μScm^{-1}	<1	1757	1965	2202	2401	3480	2115	2014
EC Field	μScm^{-1}		1723	1971	2220	2460	3430	2160	1964
Dissolved Oxygen	mg/L		0.26	0.26	0.24	0.46	0.27	0.35	0.23
Alkalinity as $CaCO_3$	mg/L	<1	39	28	8	30	NP	NP	<1
Carbonate (CO_3)	mg/L	<1	NP	NP	NP	NP	NP	NP	NP
Bicarbonate HCO_3	mg/L	<1	24	17	5	18	NP	NP	<1
Chloride	mg/L	<3	7	9	48	7	11	9	9
Sulphur as Sulphate	mg/L	<0.1	842	1006	1382	1337	1495	1418	1083
Calcium	mg/L	<0.1	121	125	161	169	165	155	128
Magnesium	mg/L	<0.1	112	71	89	<5	124	128	111
Sodium	mg/L	<0.1	10	9.5	13	12	9	11	9.2
Potassium M8	mg/L	<5	<5	<5	<5	86	<5	<5	<5
Aluminium (Total)	mg/L	<0.01	7.13	6.25	8.39	8.98	21	9.84	6.77
Aluminium (Soluble)	mg/L	<0.01	4.71	4.16	6.71	8	18	8.37	5.67
Cadmium (Total)	mg/L	<0.001	0.008	0.012	0.015	0.002	0.021	0.011	0.008
Cadmium (Soluble)	mg/L	<0.001	0.008	0.012	0.011	0.002	0.021	0.011	0.008
Copper (Total)	mg/L	<0.01	0.52	0.81	0.7	0.76	2.95	0.45	0.33
Copper (Soluble)	mg/L	<0.01	0.29	0.17	0.4	0.55	2.27	0.28	0.22
Iron (Total)	mg/L	<0.01	89	192	272	247	117	146	47
Iron (Soluble)	mg/L	<0.01	83	172	253	235	103	128	31
Manganese (Total)	mg/L	<0.01	50	52	65	64	86	78	70
Manganese (Soluble)	mg/L	<0.01	47	48	60	61	84	78	69

Groundwater Samples - MB4

Analyte	Units	LOR	9/02/2010	25/03/2010	19/04/2010	26/05/2010	21/06/2010	21/07/2010	31/08/2010
pH Lab	pH units	<0.1	6.7	6.6	6.7	6.6	6.6	6.5	6.5
pH Field	pH units		6.57	6.09	6.15	5.98	6.08	6.38	-
EC Lab	μScm^{-1}	<1	1351	1386	1374	1391	1409	1312	1378
EC Field	μScm^{-1}		1106	1365	1393	1417	1428	1390	-
Dissolved Oxygen	mg/L		0.58	0.3	0.21	0.33	0.33	0.15	0.15
Alkalinity as $CaCO_3$	mg/L	<1	220	210	210	210	220	210	220
Carbonate (CO_3)	mg/L	<1	NP	NP	NP	NP	NP	NP	NP
Bicarbonate HCO_3	mg/L	<1	134	128	128	127	135	131	134
Chloride	mg/L	<3	24	25	12	20	30	24	25
Sulphur as Sulphate	mg/L	<0.1	471	506	597	524	520	613	638
Calcium	mg/L	<0.1	150	163	191	169	161	193	204
Magnesium	mg/L	<0.1	64	65	75	<5	64	79	78
Sodium	mg/L	<0.1	23	23	25	23	21	26	25
Potassium M8	mg/L	<5	<5	<5	<5	68	<5	<5	<5
Aluminium (Total)	mg/L	<0.01	16	24	27	4.87	40	17	4.01
Aluminium (Soluble)	mg/L	<0.01	0.05	0.03	0.02	0.06	0.07	0.23	0.09
Cadmium (Total)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium (Soluble)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Total)	mg/L	<0.01	0.09	0.19	0.13	0.05	0.17	0.07	0.04
Copper (Soluble)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron (Total)	mg/L	<0.01	38	42	45	19	59	35	17
Iron (Soluble)	mg/L	<0.01	18	13	17	12	13	13	12
Manganese (Total)	mg/L	<0.01	7.55	7.64	7.69	5.78	8.27	7.29	6.15
Manganese (Soluble)	mg/L	<0.01	7.11	5.75	6.88	5.11	5.13	5.35	5.24

Surface Water Samples - KIN3

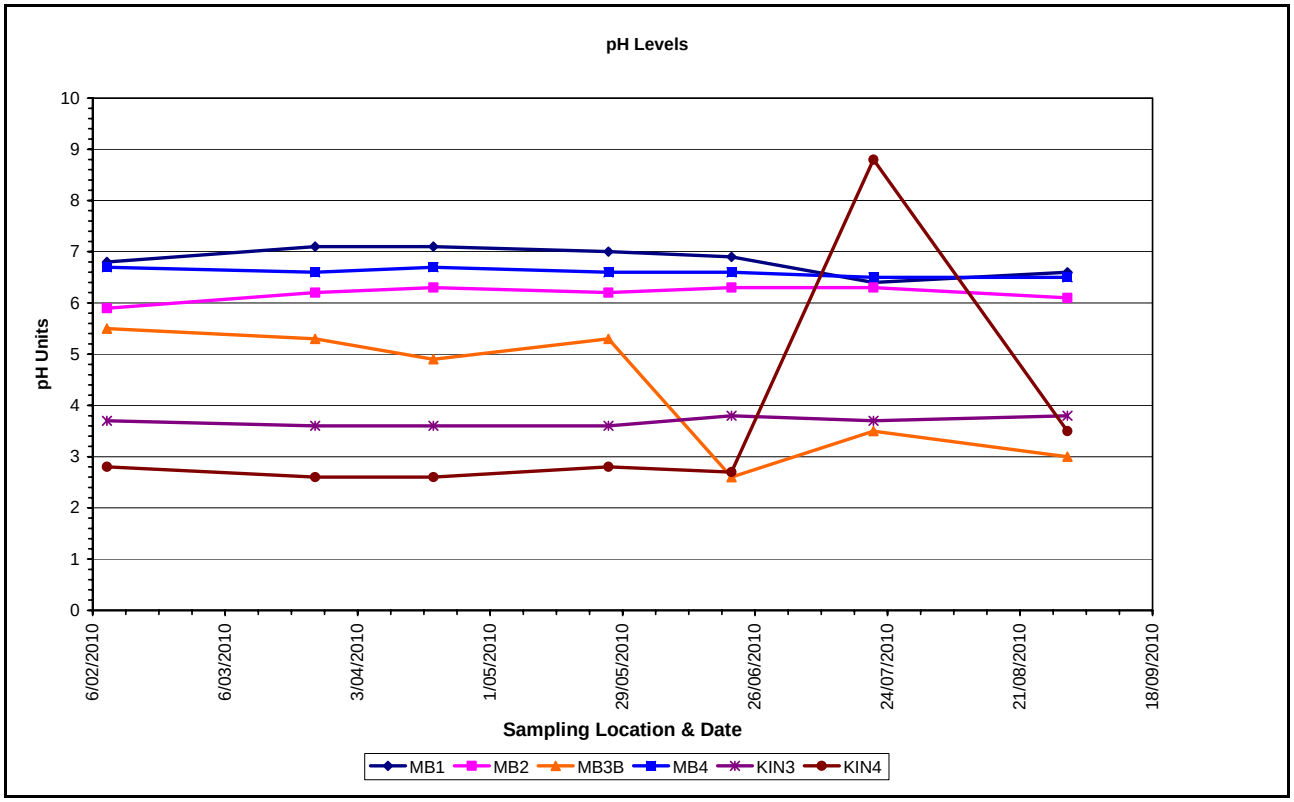
Analyte	Units	LOR	9/02/2010	25/03/2010	19/04/2010	26/05/2010	21/06/2010	21/07/2010	31/08/2010
pH Lab	pH units	<0.1	3.7	3.6	3.6	3.6	3.8	3.7	3.8
pH Field	pH units		3.38	3.44	3.45	3.39	3.48	3.59	-
EC Lab	μScm^{-1}	<1	348	401	418	377	360	343	368
EC Field	μScm^{-1}		367	390	403	368	347	343	-
Dissolved Oxygen	mg/L		6.18	3.2	2.33	2.41	5.16	3.4	1.39
Alkalinity as $CaCO_3$	mg/L	<1	NP	NP	NP	<1	NP	NP	<1
Carbonate (CO_3)	mg/L	<1	NP	NP	NP	NP	NP	NP	NP
Bicarbonate HCO_3	mg/L	<1	NP	NP	NP	<1	NP	NP	<1
Chloride	mg/L	<3	9	14	17	12	21	15	15
Sulphur as Sulphate	mg/L	<0.1	94	113	131	101	113	114	132
Calcium	mg/L	<0.1	12	14	16	11	12	14	15
Magnesium	mg/L	<0.1	6.8	7.5	9	<5	7.7	9	9.5
Sodium	mg/L	<0.1	9	11	14	12	14	15	15
Potassium M8	mg/L	<5	<5	<5	<5	7	<5	<5	<5
Aluminium (Total)	mg/L	<0.01	3.5	3.69	4.45	2.99	2.63	2.5	2.78
Aluminium (Soluble)	mg/L	<0.01	3.27	3.52	4.12	2.95	2.63	2.5	2.77
Cadmium (Total)	mg/L	<0.001	0.001	0.001	0.001	<0.001	0.001	0.001	0.001
Cadmium (Soluble)	mg/L	<0.001	0.001	0.001	0.001	<0.001	<0.001	0.001	0.001
Copper (Total)	mg/L	<0.01	0.59	0.47	0.47	0.36	0.24	0.21	0.2
Copper (Soluble)	mg/L	<0.01	0.54	0.36	0.41	0.34	0.24	0.21	0.16
Iron (Total)	mg/L	<0.01	2.21	2.07	1.6	1.6	0.92	1.2	1.94
Iron (Soluble)	mg/L	<0.01	1.84	1.1	0.87	0.58	0.61	0.77	1.7
Manganese (Total)	mg/L	<0.01	4.28	5.98	7.84	5.5	6.39	7.03	8.13
Manganese (Soluble)	mg/L	<0.01	4.1	5.87	7.42	5.5	6.39	7.03	8.13

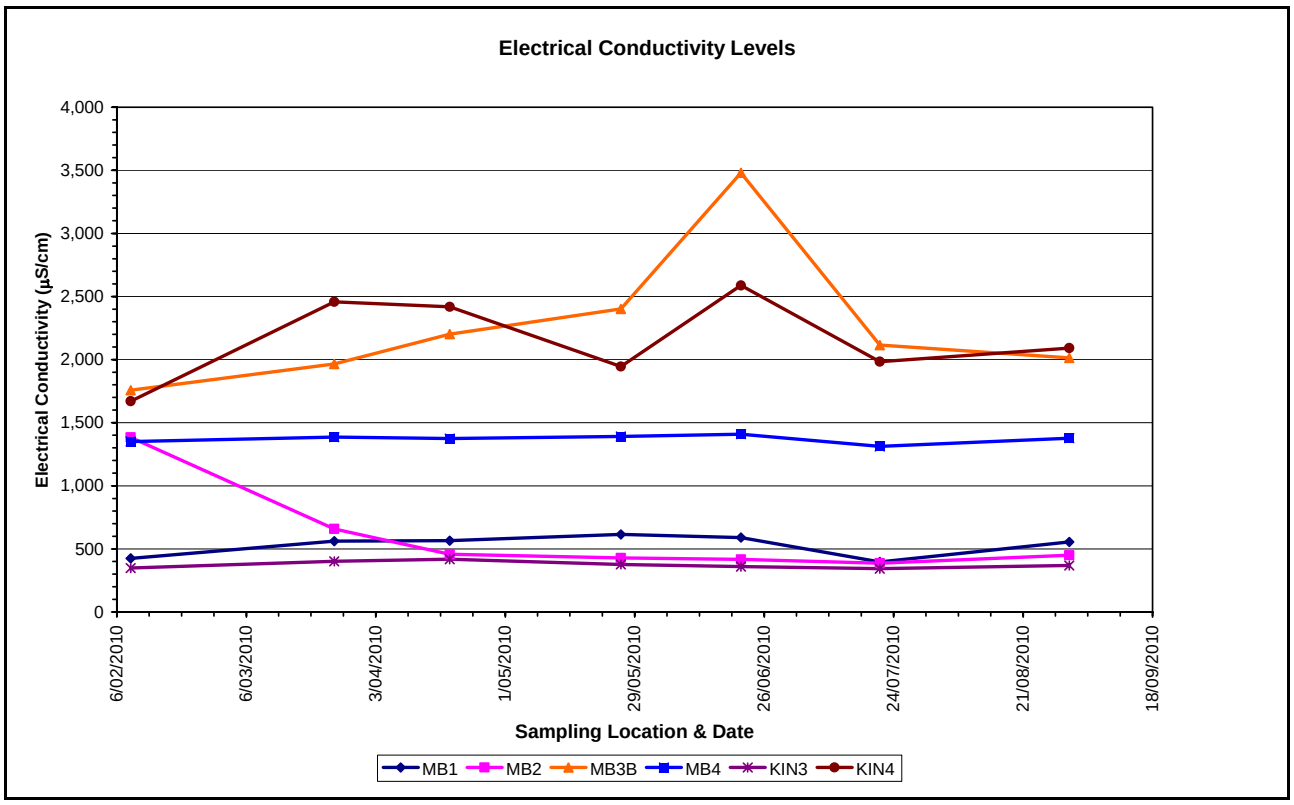
Surface Water Samples - KIN4

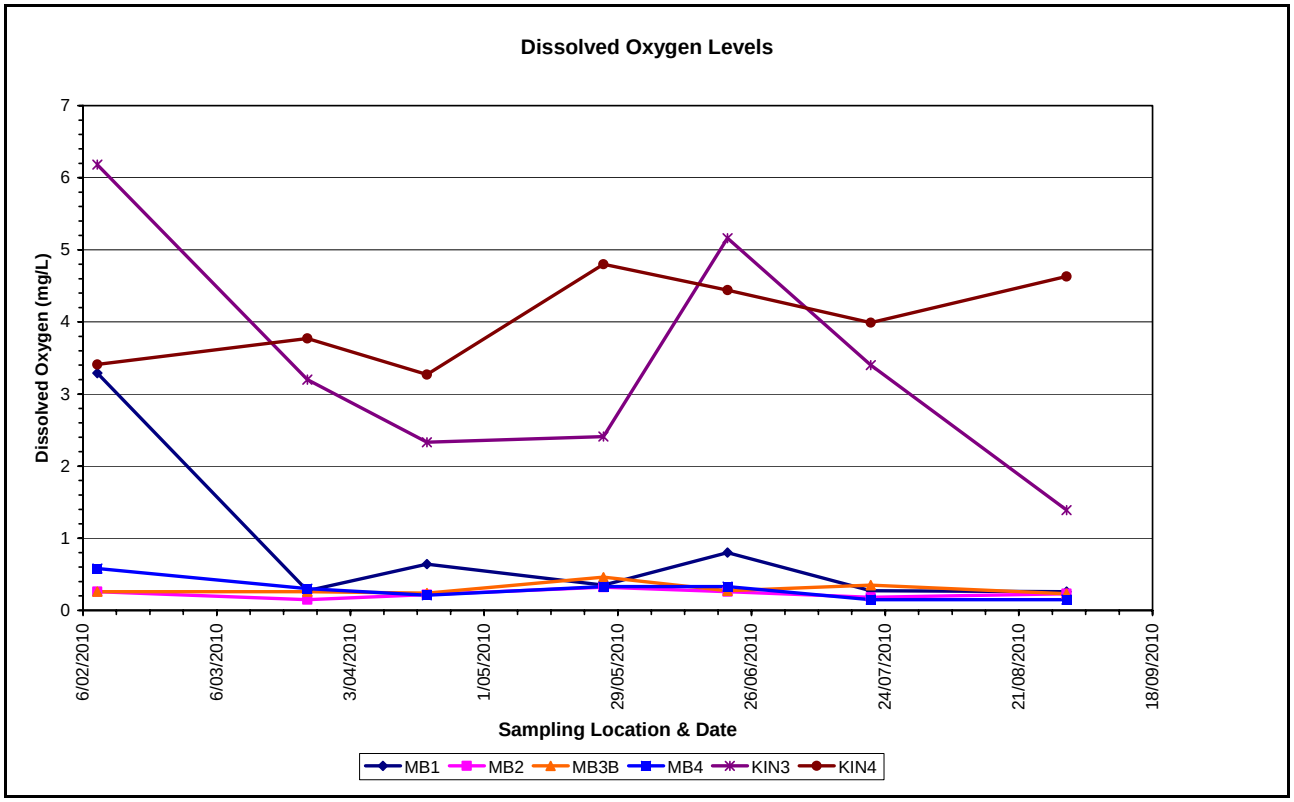
Analyte	Units	LOR	9/02/2010	25/03/2010	19/04/2010	26/05/2010	21/06/2010	21/07/2010	31/08/2010
pH Lab	pH units	<0.1	2.8	2.6	2.6	2.8	2.7	8.8	3.5
pH Field	pH units		2.87	2.87	2.73	2.8	2.82	8.57	-
EC Lab	μScm^{-1}	<1	1671	2458	2418	1945	2588	1984	2092
EC Field	μScm^{-1}		1571	2300	2400	1912	2510	2110	-
Dissolved Oxygen	mg/L		3.41	3.77	3.27	4.8	4.44	3.99	4.63
Alkalinity as $CaCO_3$	mg/L	<1	NP	NP	NP	<1	NP	62	<1
Carbonate (CO_3)	mg/L	<1	NP	NP	NP	NP	NP	7	NP
Bicarbonate HCO_3	mg/L	<1	NP	NP	NP	<1	NP	31	<1
Chloride	mg/L	<3	4	9	10	6	13	10	11
Sulphur as Sulphate	mg/L	<0.1	628	1096	1299	847	1209	1417	1371
Calcium	mg/L	<0.1	110	151	170	132	175	482	421
Magnesium	mg/L	<0.1	38	58	72	<5	66	67	59
Sodium	mg/L	<0.1	11	8.3	8.9	7.5	8.6	9.8	9.2
Potassium M8	mg/L	<5	6	<5	<5	50	<5	<5	5
Aluminium (Total)	mg/L	<0.01	13	9.95	9.46	7.34	10	0.08	3.04
Aluminium (Soluble)	mg/L	<0.01	12	9.71	9.01	6.99	9.33	0.03	3.04
Cadmium (Total)	mg/L	<0.001	0.005	0.007	0.006	<0.001	0.007	<0.001	0.003
Cadmium (Soluble)	mg/L	<0.001	0.005	0.007	0.006	<0.001	0.007	<0.001	0.002
Copper (Total)	mg/L	<0.01	0.88	0.33	0.18	0.17	0.13	<0.01	0.03
Copper (Soluble)	mg/L	<0.01	0.81	0.24	0.16	0.15	0.12	<0.01	<0.01
Iron (Total)	mg/L	<0.01	30	94	125	64	100	0.41	4.84
Iron (Soluble)	mg/L	<0.01	27	93	121	60	96	0.01	4.55
Manganese (Total)	mg/L	<0.01	20	39	50	31	43	11	33
Manganese (Soluble)	mg/L	<0.01	18	39	48	30	42	8.17	32

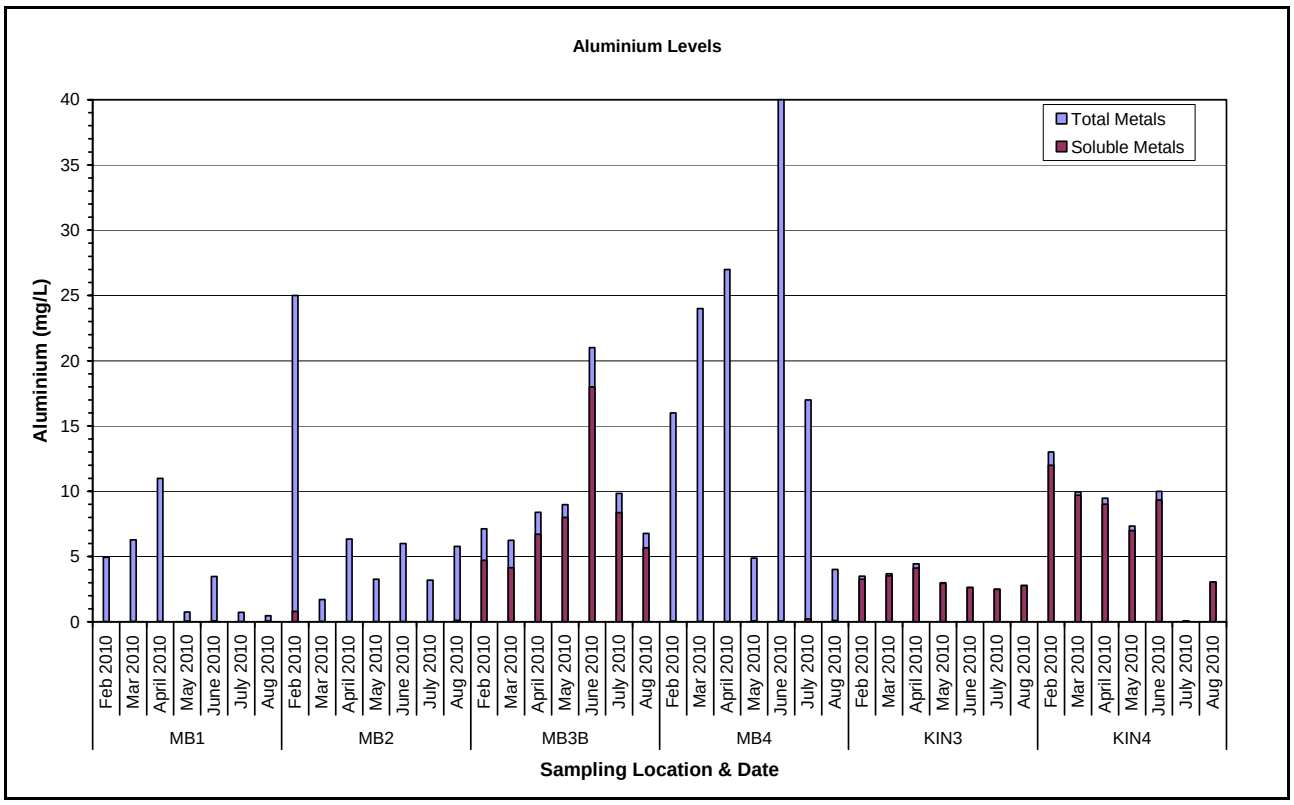
Appendix E

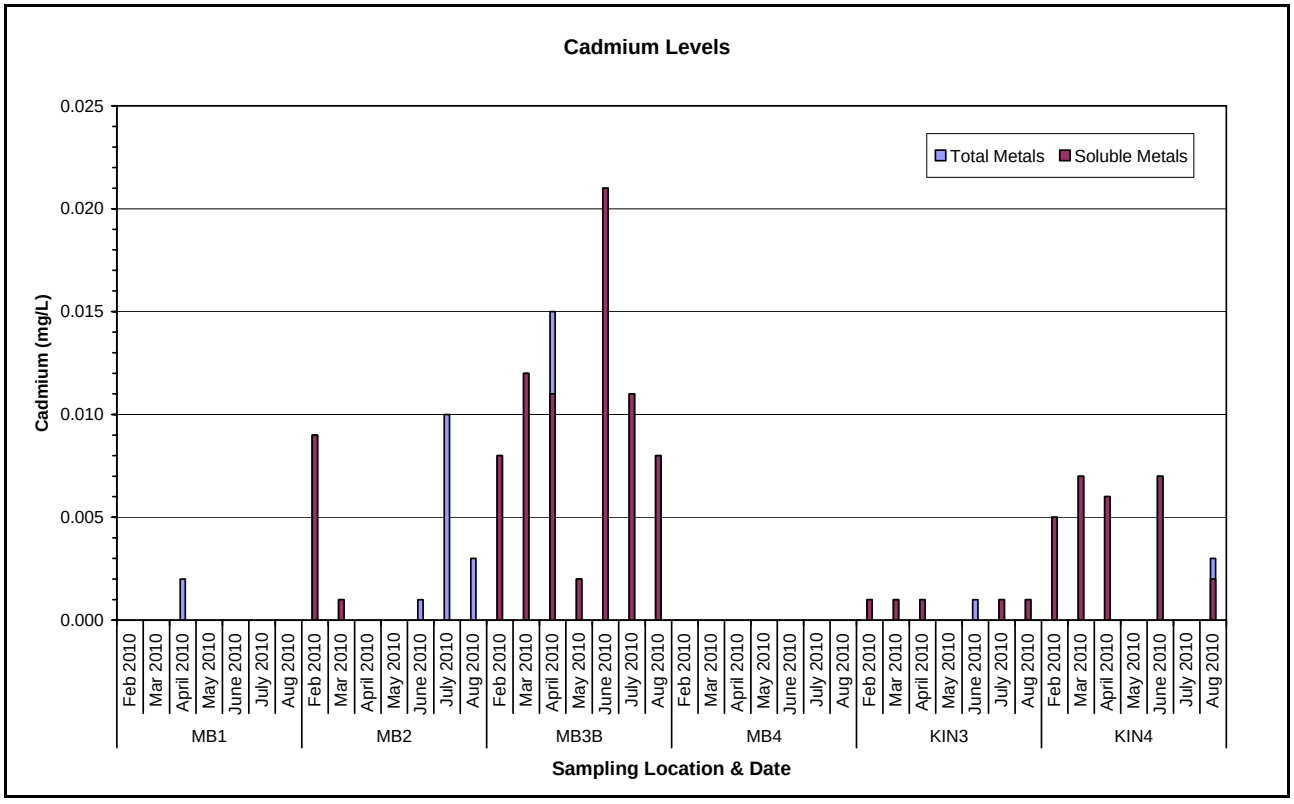
GRAPHICAL PRESENTATION OF WATER QUALITY RESULTS

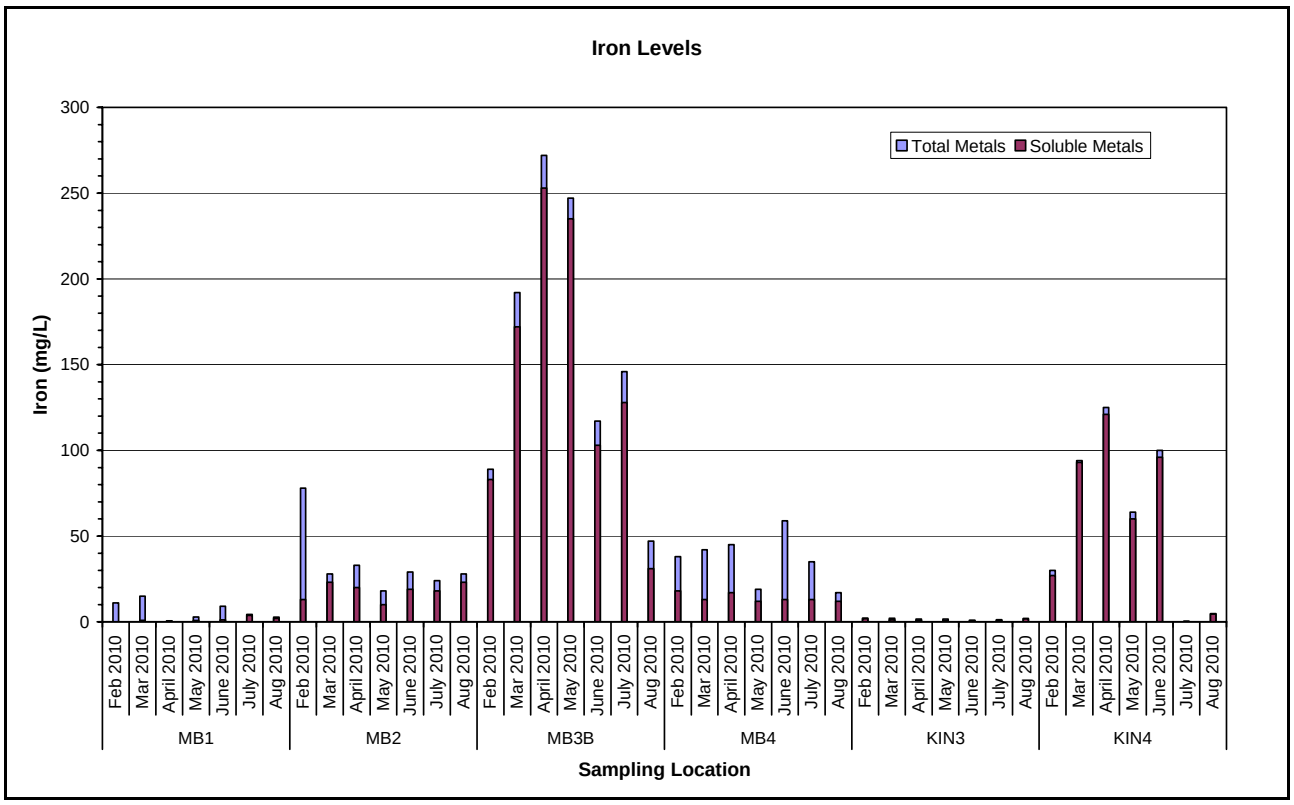

pH Levels
pH Units
10
9
8
7
6
5
4
3
2
1
0
6/02/2010
6/03/2010
3/04/2010
1/05/2010
29/05/2010
26/06/2010
24/07/2010
21/08/2010
18/09/2010
Sampling Location & Date
MB1
MB2
MB3B
MB4
KIN3
KIN4

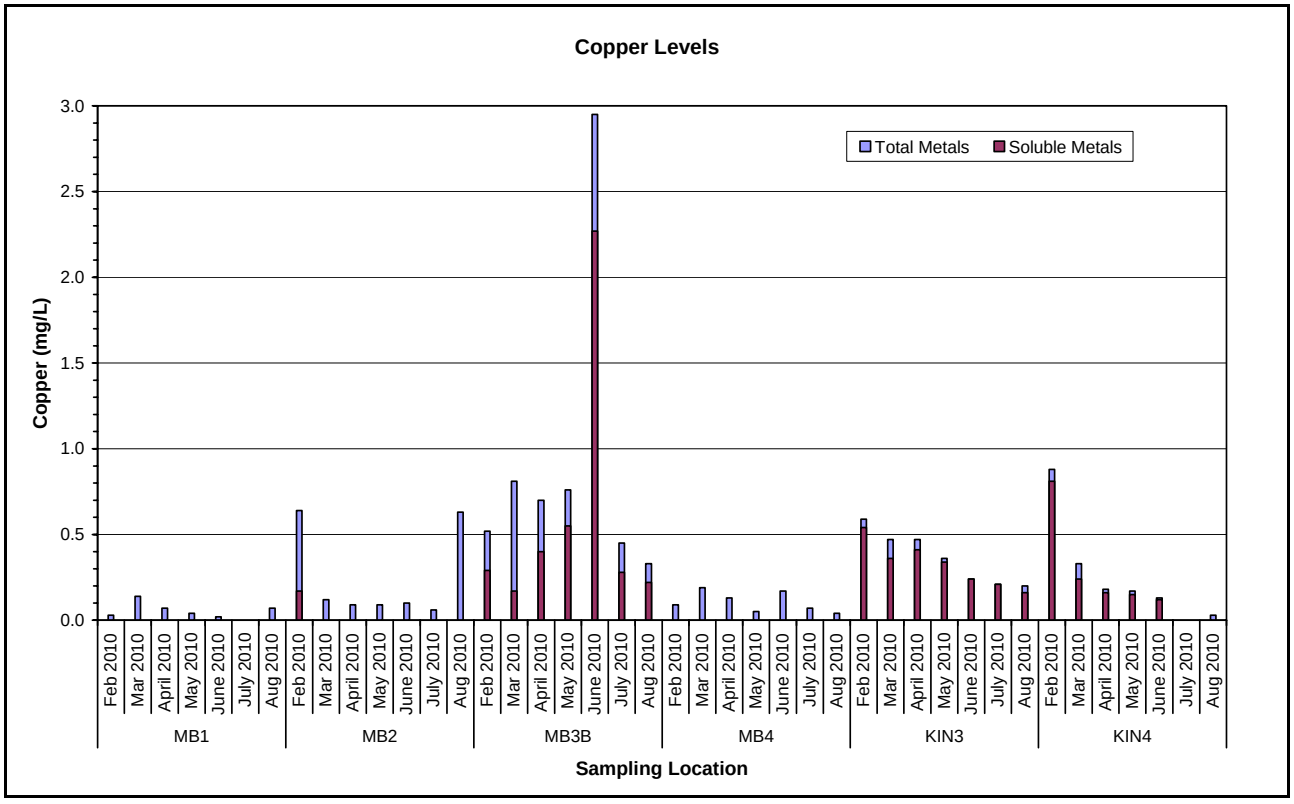

Electrical Conductivity Levels
Electrical Conductivity (µS/cm)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
6/02/2010
6/03/2010
3/04/2010
1/05/2010
29/05/2010
26/06/2010
24/07/2010
21/08/2010
18/09/2010
Sampling Location & Date
MB1
MB2
MB3B
MB4
KIN3
KIN4

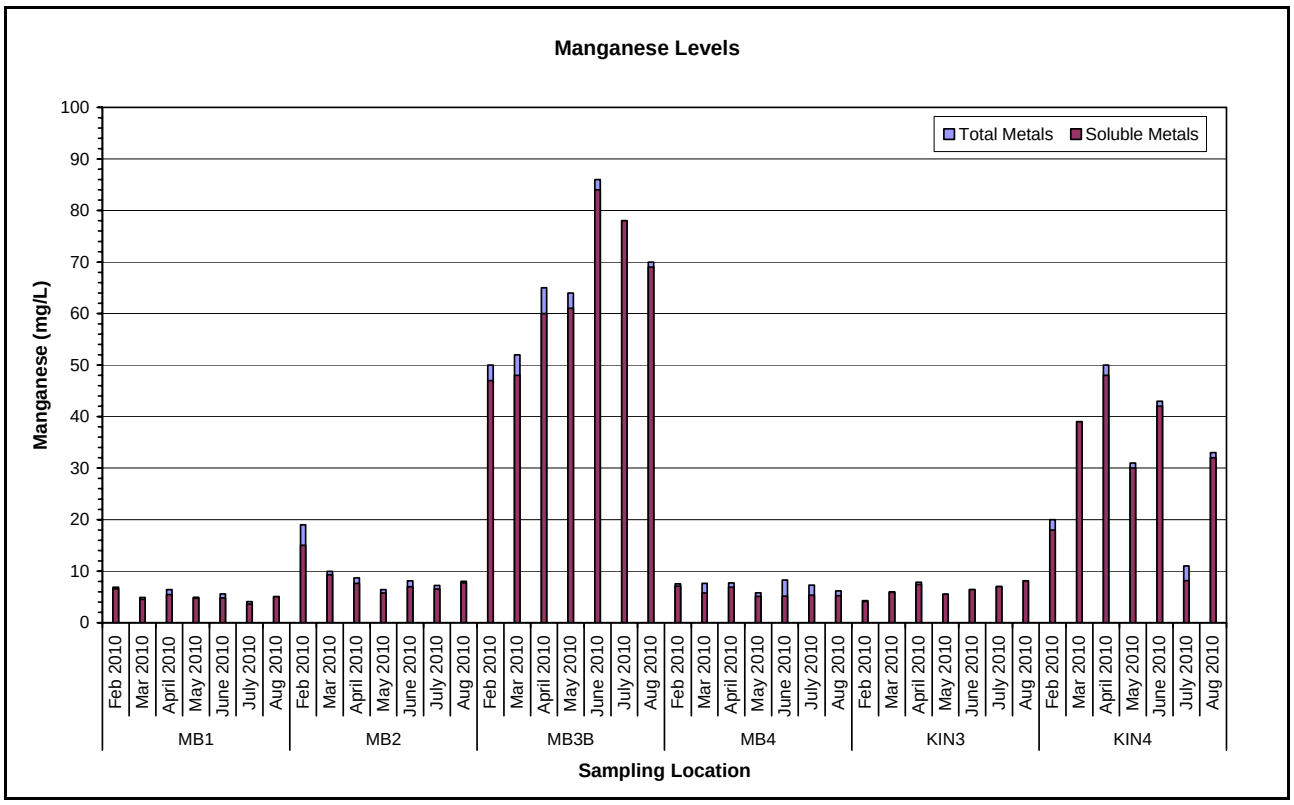

Dissolved Oxygen Levels
Dissolved Oxygen (mg/L)
0
1
2
3
4
5
6
7
6/02/2010
6/03/2010
3/04/2010
1/05/2010
29/05/2010
26/06/2010
24/07/2010
21/08/2010
18/09/2010
Sampling Location & Date
MB1
MB2
MB3B
MB4
KIN3
KIN4


Aluminium Levels
Aluminium (mg/L)
0
5
10
15
20
25
30
35
40
Total Metals
Soluble Metals
Feb 2010
Mar 2010
April 2010
May 2010
June 2010
July 2010
Aug 2010
MB1
MB2
MB3B
MB4
KIN3
KIN4
Sampling Location & Date


Cadmium Levels
Total Metals
Soluble Metals
Cadmium (mg/L)
0.025
0.020
0.015
0.010
0.005
0.000
Feb 2010
Mar 2010
April 2010
May 2010
June 2010
July 2010
Aug 2010
MB1
MB2
MB3B
MB4
KIN3
KIN4
Sampling Location & Date


Iron Levels
Total Metals
Soluble Metals
Iron (mg/L)
300
250
200
150
100
50
0
Feb 2010
Mar 2010
April 2010
May 2010
June 2010
July 2010
Aug 2010
MB1
MB2
MB3B
MB4
KIN3
KIN4
Sampling Location


Copper Levels
Copper (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Total Metals
Soluble Metals
Feb 2010
Mar 2010
April 2010
May 2010
June 2010
July 2010
Aug 2010
MB1
MB2
MB3B
MB4
KIN3
KIN4
Sampling Location


Manganese Levels
Manganese (mg/L)
100
90
80
70
60
50
40
30
20
10
0
Total Metals
Soluble Metals
Feb 2010
Mar 2010
April 2010
May 2010
June 2010
July 2010
Aug 2010
MB1
MB2
MB3B
MB4
KIN3
KIN4
Sampling Location

Appendix F

PIPER AND STIFF DIAGRAMS

Piper Diagrams of Groundwater and Surface Water Quality

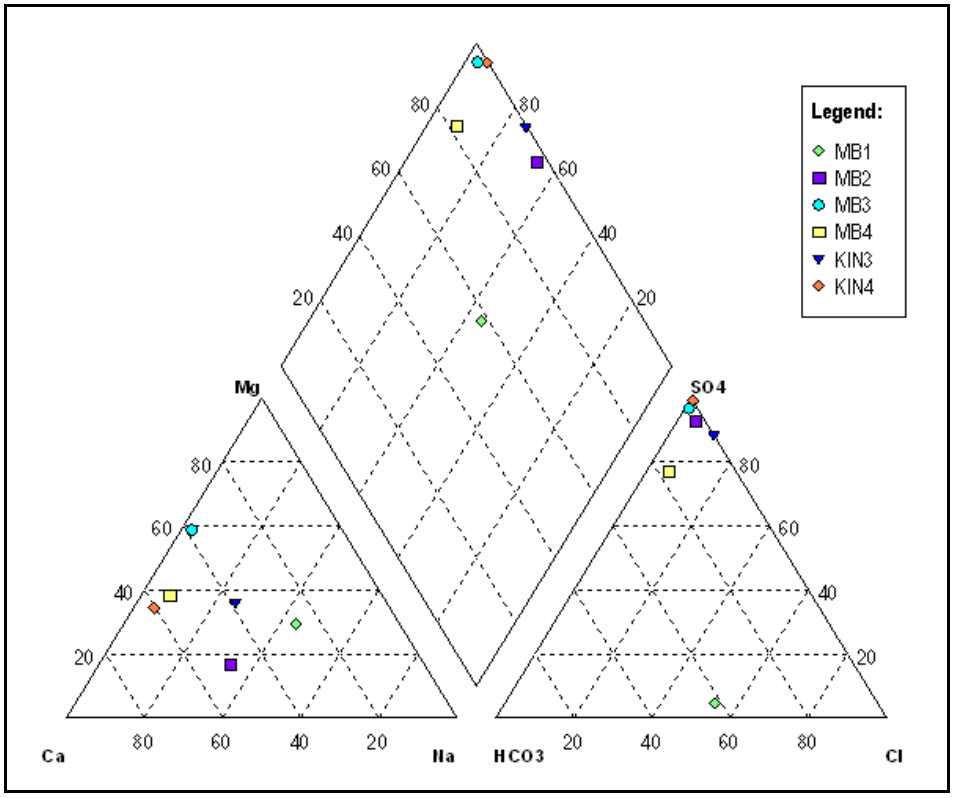


Figure F1: February 2010

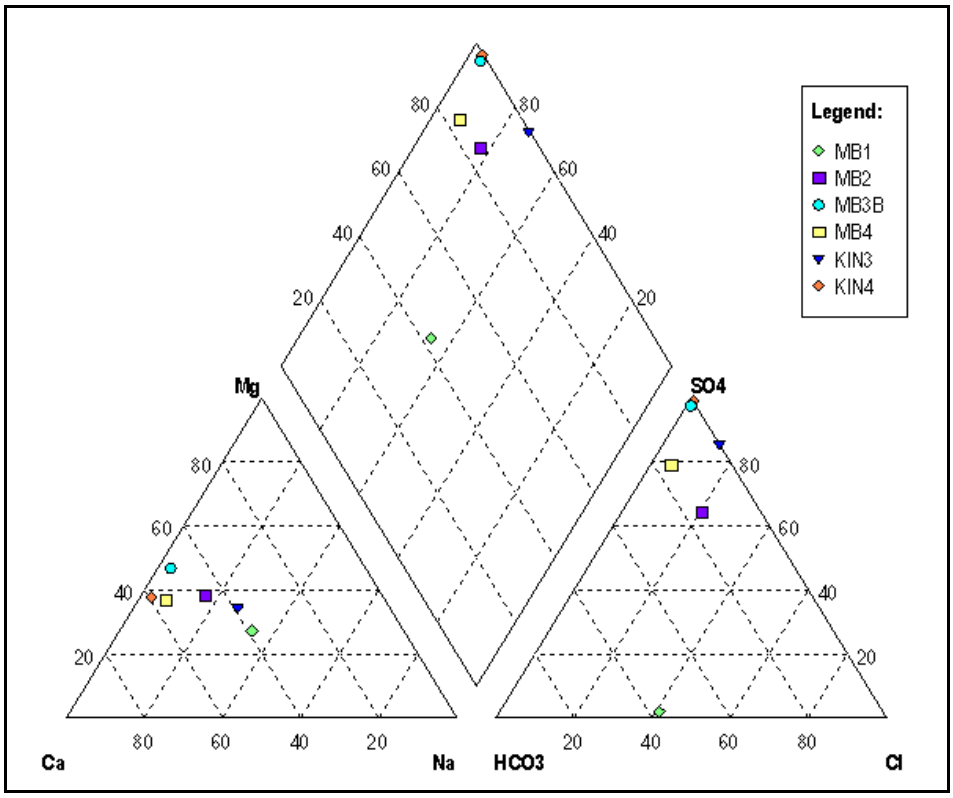


Figure F2: March 2010

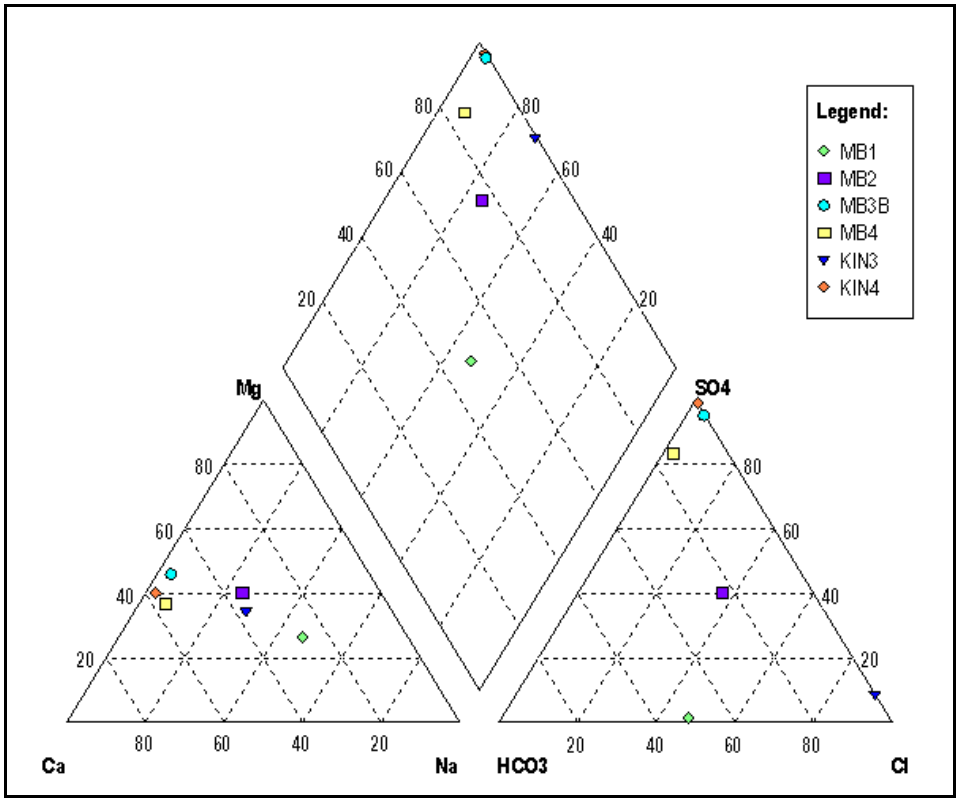


Figure F3: April 2010

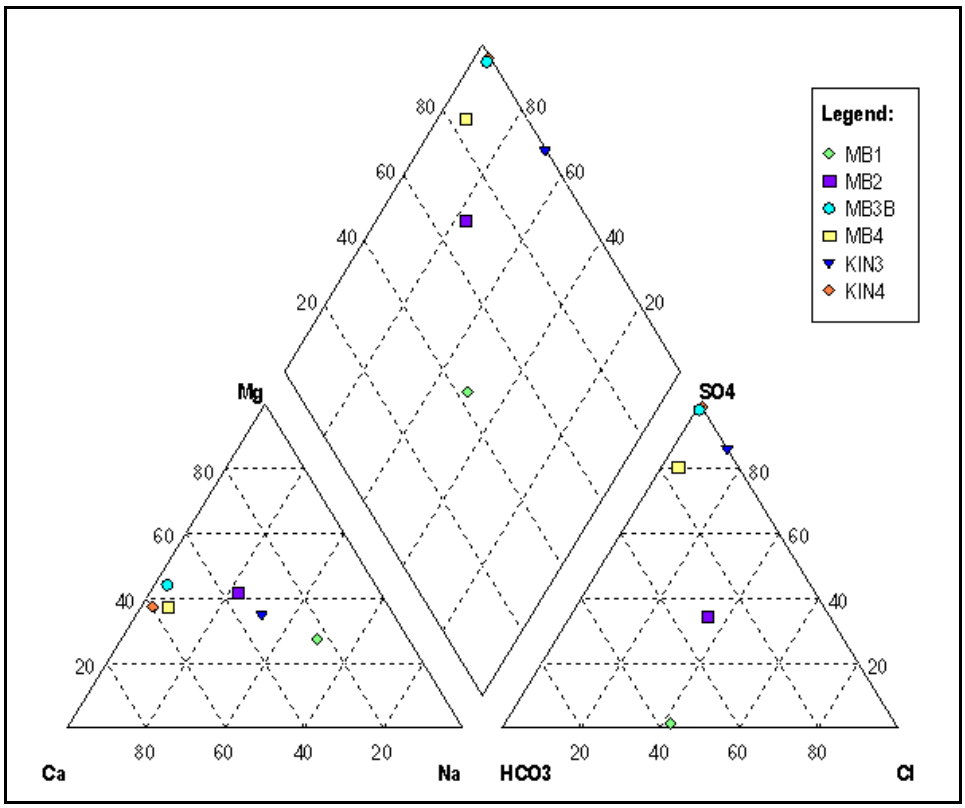


Figure F4: May 2010

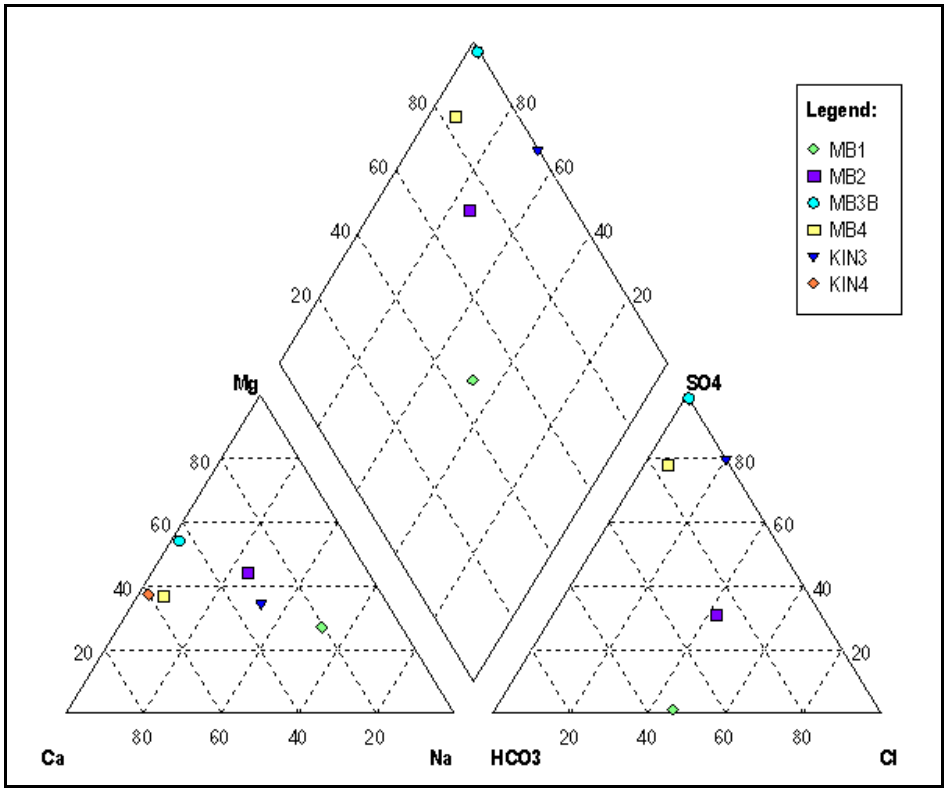


Figure F5: June 2010

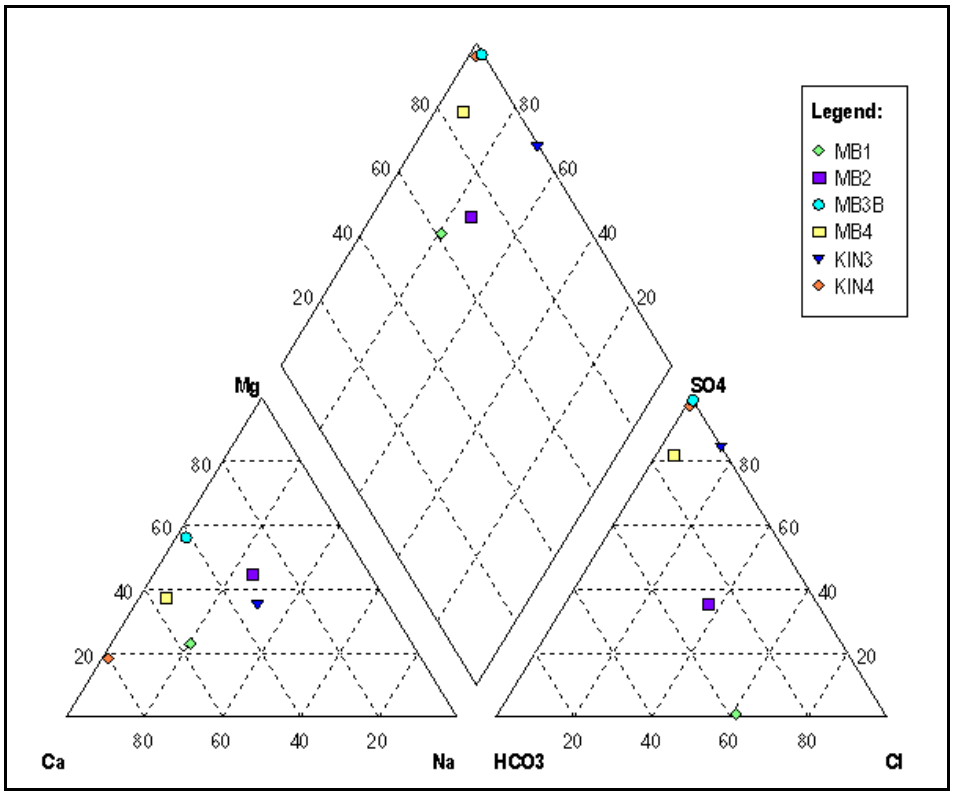


Figure F6: July 2010

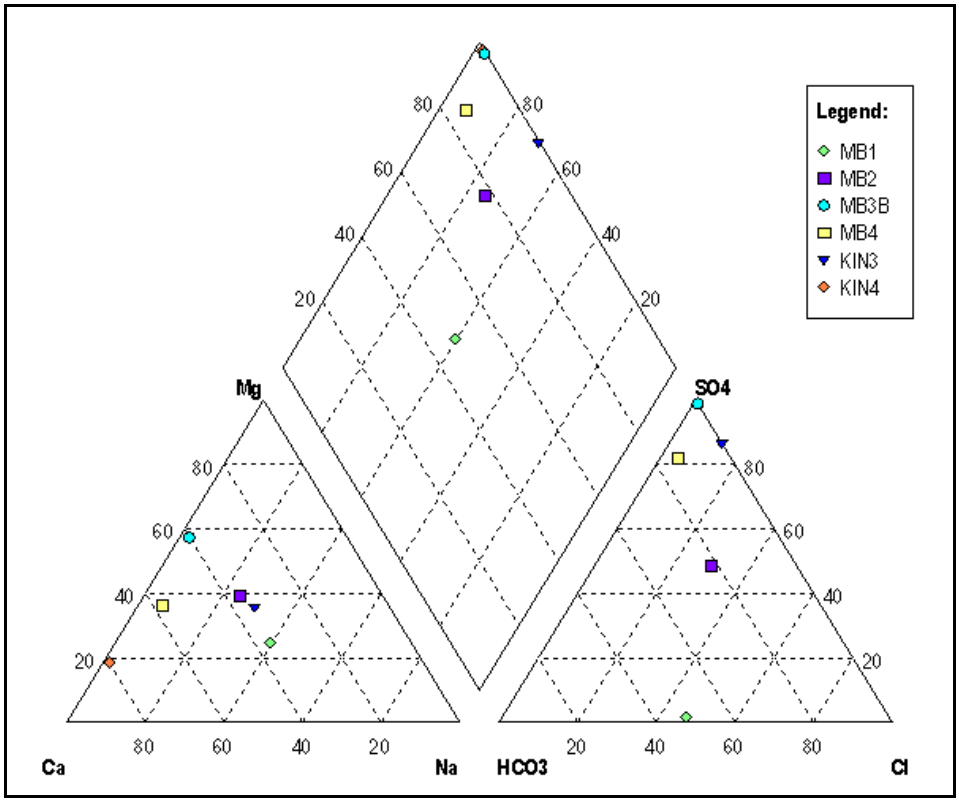


Figure F7: August 2010

Stiff Diagrams of Groundwater and Surface Water Quality

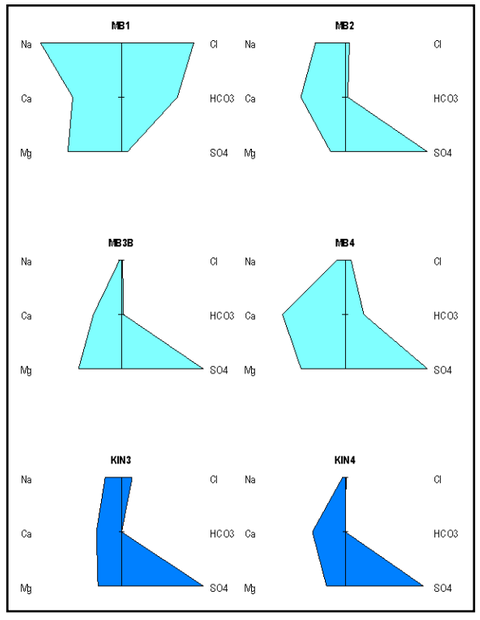


Figure F8: February 2010

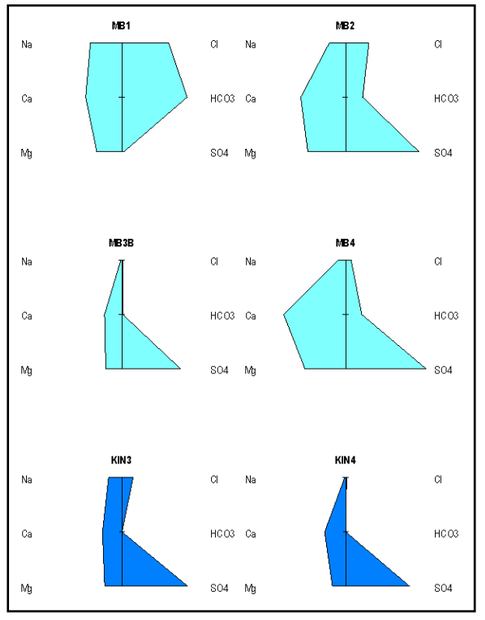


Figure F9: March 2010

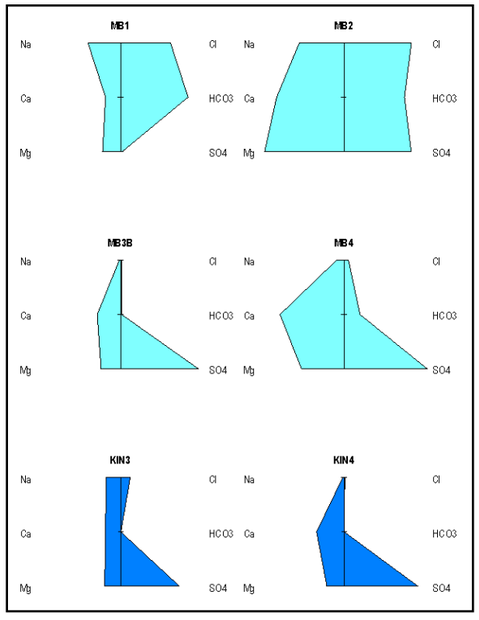


Figure F10: April 2010

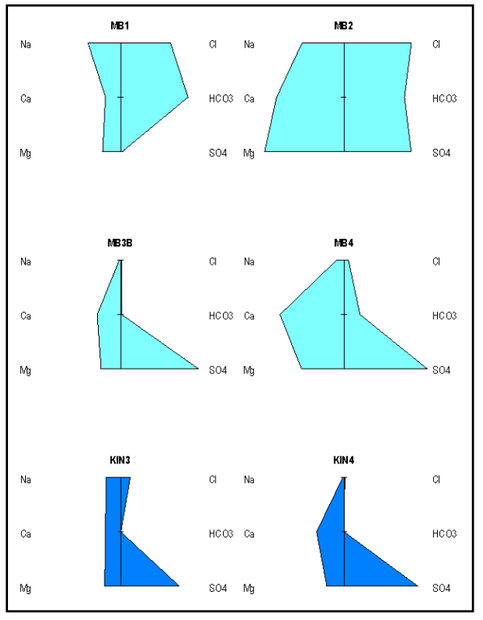


Figure F11: May 2010

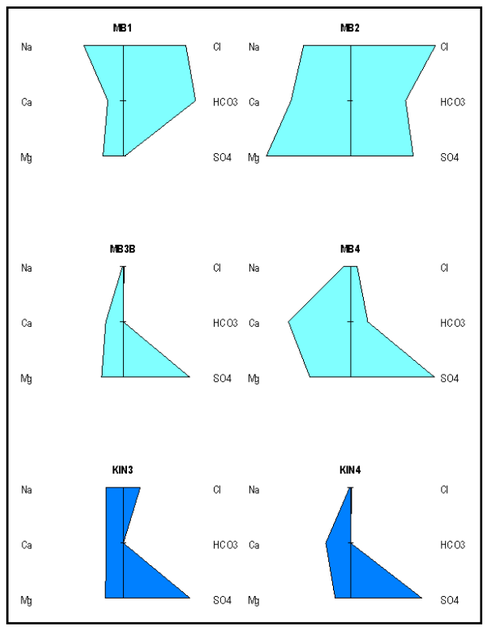


Figure F12: June 2010

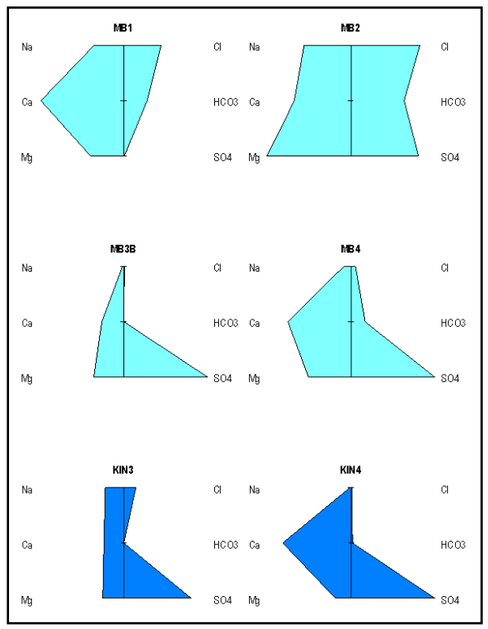


Figure F13: July 2010

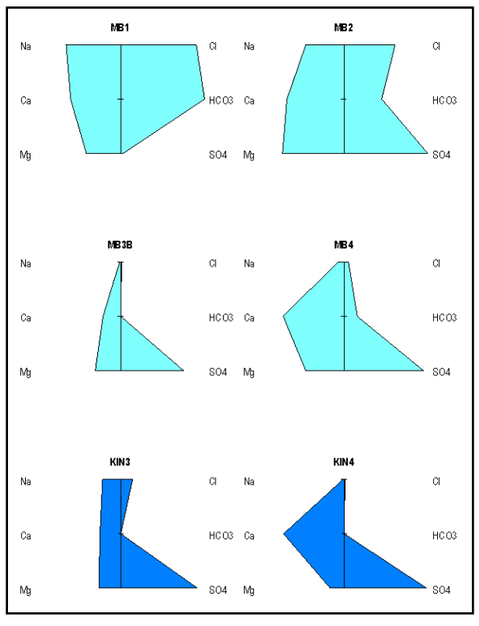


Figure F14: August 2010

Note this page should be printed to A3